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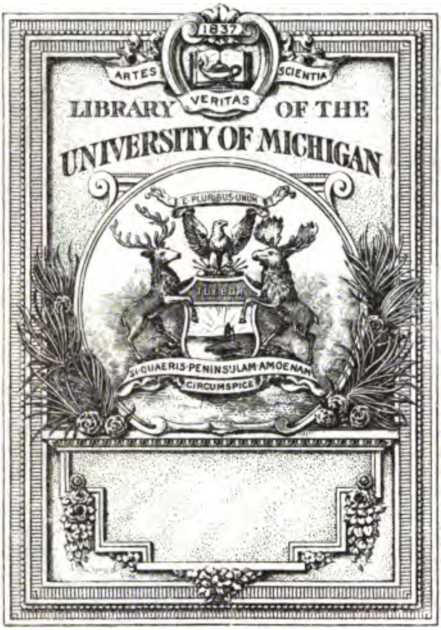

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FIRST

ANNUAL REPORT

OF THE

STATE GEOLOGIST.

READ IN THE HOUSE OF REPRESENTATIVES, DECEMBER 22, 1836.

HARRISBURG:
PRINTED BY SAMUEL D. PATTERSON.
1836

PNE-H

REPORT.

Hon. **Lewis Dewart**, Esq.

Speaker of the House of Representatives.

Sir:—I have the honor to transmit for the use of the Legislature, the first annual report of Professor Rogers, as State Geologist, in conformity with the third section of the act of 29th March, 1836, relative to a Geological and Mineralogical survey of the state.

The Governor, who has examined the report, authorizes me to state, that he concurs in bespeaking the favorable attention of the general assembly to that part of it, which relates to an increase in the number of Assistant Geologists. The soundest prudence dictates that all necessary facility shall be afforded to this important undertaking. By complying with the request of the chief Geologist, now, the final completion of the survey will be hastened, without adding to the aggregate ultimate expense, and the public will be sooner put in possession of that certainty of result which is so desirable in every respect.

It is prescribed by the act above cited, that the annual report shall be made "on or before the first of January in each and every year." I am requested by the chief Geologist to state that this provision is extremely inconvenient in practice. The time which elapses between the termination of field operations, and the first of January is too brief for the necessary chemical analyses and other details of the report. If it remain unchanged, it may hereafter either cause the preparation of a supplemental annual report, or the postponement for a whole year, of the communication to the legislature of the most valuable part of the operations of the season. It is, therefore, respectfully suggested, that the time of making the report be extended until the first day of February in each year.

I am sir,
With great respect,
THOS. H. BURROWES,
Secretary of the Commonwealth.

Secretary's Office, Harrisburg,
December 22, 1836.

To the Secretary of the Commonwealth of Pennsylvania.

Sir—In obedience to the act of the legislature, providing for a Geological and Mineralogical survey of the state, with the duty of conducting which I have had the honor to be entrusted, the following report is respectfully offered. Its object is to communicate the outlines of the plan which has been adopted for ascertaining the mineral resources of Pennsylvania, and the extent of the researches thus far made in pursuance of that plan, embracing some of the general results which have been obtained. Influenced, however, by considerations of obvious importance to the ultimate consistency and value of the work, I shall submit at present a small portion only of the materials in my possession, reserving for future publication all such observations as might, possibly, in the incipient stage of the survey, be regarded either as incomplete, from an inadequate collection of facts, or as involving, from want of opportunities for their revision, any inaccurate or immature inferences. For the course proposed, I am happy to perceive ample warrant in the terms of the law which in the 3rd section, calls only for annual reports of the progress "from time to time made in the survey," and in the 4th section does not require to be compiled, a memoir on the Geology and Mineralogy of the state, until the completion of the survey." To remove, in the mean time, any unfounded expectation on the part of the public, in regard to future publications, I beg leave to state, in confirmation of the views which appear to have already influenced the legislature on this subject, a few of the reasons, which, in my opinion, most strongly recommend the expediency of withholding the details annually collected, in order to embody them, at the termination of the survey, in one comprehensive description of the state. The liability to commit serious errors during the earlier steps of a geological investigation, devoted to a country so little explored as Pennsylvania, is obvious, and that risk is in this instance rendered more imminent by the enormous magnitude of our formations, to understand any one of which correctly, it becomes requisite to traverse very extensive districts. In researches of a character so complex as some of those which offer themselves in the exploration of such a territory, no conclusion ought to be admitted as sound, until all branches of the investigation intimately dependent upon each other for mutual elucidation, have received their appropriate share of study. Inquirers demanding the united aid of geological, mineralogical and chemical data, collected from various sources, absolutely require, if we would give them all the precision which is essential to their practical value, frequent and elaborate re-examinations of the phenomena. It ought to be borne in mind, too, that in geology whose aims are eminently practical, it frequently happens that useful results connected with the arts, are involved in the higher generalizations of the science, and are consequently the latest reached—and a further powerful motive for perfecting our observations before we venture to give them currency, is afforded by the reflection, that those conclusions at which we are most anxious to arrive, are of a kind bearing necessarily upon many private interests, and tending to operate widely on the industry and capital of the country. An additional inducement for postponing to one final report, in accordance with the law, the great body of the observations to be collected arises from the importance justly attached to the chemical researches connected with the survey, which can hardly fail ultimately to constitute one of its principal merits on the score of beneficial applications. To deduce from the chemical examinations those more profitable results for which they are expressly undertaken, a multitude of specimens of each separate class, and from distant localities, ought to be compared, and their peculiarities made known through analysis. The light thus acquired respecting their constitution, and the probable cause of their varied combination, becomes a fresh and powerful auxiliary to discovery, by suggesting new views of their geological relations, and by leading to numerous highly useful conclusions otherwise unattainable. Chemical researches so conducted, will demand for their execution much time before their more important results are in a state to be made public, and since it is in contemplation to annex to a certain portion of the specimens in the cabinet their chemical composition, it is conceived that until these become susceptible of final classification and arrangement, a detail of the chemical facts ascertained, must be deprived of more than half its value. Add to these arguments the consideration, that before the minutia of description belonging to any portion of our geology, even so much of it as might be conveyed in a brief annual report, could be properly understood, or correctly appreciated, it would be indispensable to furnish the reader with some means of reference to a geological map, and a cabinet of our minerals, neither of which, it is obvious, can be produced in such a shape as to be useful, until a much later stage of the survey. The state map cannot well be published until fully completed, owing to the necessity of re-engraving some parts of its topography, and of tracing on it the range of the several formations, while the cabinet must receive numerous accessions, and will require much chemical labor to be bestowed on it, ere the work of arrangement can be ~~entered on~~ without incurring a serious sacrifice of time, which would be much better devoted at present to other duties of the survey. Both the geological state map, and the state cabinet will, like the definitive report designed to accompany them, gain much in point of accuracy, and therefore of usefulness, if permitted to remain, subject to revision, in such a shape as to admit of successive improvements from the annually increasing mass of objects and of information which it is so desirable they should ultimately embrace.

That the legislature may be informed in what manner and to what extent the duties assigned me have been discharged, I beg leave to state, that upon receiving my commission as State Geologist, I proceeded as promptly as practicable to the appointment, as prescribed in the act, of two geological assistants, deferring for a few months the selection of a chemical assistant, whose services were not needed until a certain amount of specimens could be accumulated. The other necessary organizations being completed in the month of May, the investigations of the season were commenced, and these were actively prosecuted until the beginning of November. The chemical examinations were subsequently entered upon before the termination of the field explorations, and are now receiving, in conjunction with other details, their appropriate share of attention.

The first steps taken in the systematic examination of the geology and mineralogy of the state, consisted of a rapid excursion made across the ~~whole belt of our formations from the~~ Delaware river to lake Erie. This was designed as a general reconnoissance, ~~preliminary~~ in its objects, being executed chiefly for the purpose of ascertaining at one view the prominent features of the several great mineral districts of the state, as a guide to the most eligible manner of conducting the more detailed operations of the survey.

The line selected for this reconnoissance of the formations, was made to commence near the town of Chester, on the Delaware river, and to extend to the Susquehanna, near Columbia, following the valley of this river; from thence to the mouth of the Juniata, and up the latter stream as high as Lewistown. From Lewistown, its course, now more directly transverse to the range of the strata, was by Bellefonte, across the Allegheny mountain to the Susquehanna river at Karthaus. Here the south eastern half of the line terminated, and that position intended to ascertain the general features in the structure and mineral resources of the great north western division of the state was caused to commence at a point near Phillipsburg, several miles south west of the former, and in the same general north westerly course as before, to pass through Clearfield, Brookville, Franklin and Meadville, to lake Erie, terminating near the western frontier of the state. The explorations upon the same line were subsequently extended in a south eastern direction through Mount Pleasant, over the Allegheny mountain, and down the little Juniata to its mouth~~, and~~ thence by the valley of the Juniata as far as its sudden change of course at Hamiltonsville, affording thus, two independent sections across the intricate mountainous ~~district in the middle~~ of the state. As the examinations made in these introductory operations of the survey, were purposely of a cursory kind, so as to bring into view as many of the more obvious geological phenomena, as the brief time allotted to them would expose, no single or narrow line of explorations was rigorously adhered to; but, on the contrary, it was deemed advisable to carry the observations to the right and left of the line laid down, as widely as was consistent with convenience, within the limits of a moderately broad belt.

Experience during the subsequent, more exact investigations of the season has served to develope, in the most striking manner, the utility of this train of preliminary observations, for independently of the intrinsic importance of the numerous local facts collected, they soon led to certain general comparisons of the structure, resources and relations to each other of the several prominent geological districts of the state, and thus plainly indicated the steps most expedient to be adopted in undertaking the more minute inquiries of the survey.

The first and most important measure which they suggested in reference to the quarter at which to begin the delineation of the range of our several strata and mineral deposites, was the expediency of the subdivision of the state into three great tracts, namely: a south eastern, a middle and a north western region. The distinct character of these sections in their geological structure, no less than in their topographical features, and the diversity in the nature as well as in the mode of distribution of their respective mineral treasures were rendered obvious, and the necessity of exploring them separately as three detached, though closely related fields of observation became apparent. The boundary dividing the south eastern from the middle region, may be approximately traced by a line along the north western base of the irregular chain of hills, (the Blue ridge chain) ranging on the south east of the great Cumberland valley, while the ridge of the Allegheny mountain forms the line by which we propose to separate the extensive middle section from the still wider region north west of it.

For the purpose of rendering a reference to these several districts of our geology more definite, it is suggested to designate each by some sufficiently comprehensive, yet specified name. All that section of the territory of the state lying south east of the Cumberland Valley, we prefer calling for the present, and until some better title can be found, the *South eastern region*. The great middle area of Pennsylvania stretches in a general north east and south west direction from Wayne and Pike to Bedford and Franklin counties, comprising in its breadth, nearly the whole of the wide mountainous zone of the state, embraced between the south eastern region and the principal ridge of the Allegheny mountains. This I propose to call the *Appalachian region* of Pennsylvania, employing a name by which geographers sometimes designate the entire system of mountains which traverses the United States from Alabama to the head waters of the Connecticut. I thus appropriate this term, because all this middle region of the state lies within the so called Appalachian system of mountains. It is true the signification of the word has been so extended, as to comprehend the great table land of the Allegheny mountain, and its spurs, though it is greatly to be wished, for the sake of giving greater exactness to geographical reference, that this latter mountain, with the ridges west of it, should be known exclusively as the Allegheny chain; and the mountains from its base, east, to the great Cumberland Valley, exclusively as the Appalachian chain When occasional allusion may be necessary to these two systems of mountains, so dissimilar, both in their geological structure and their external configuration, we shall always employ the names Allegheny and Appalachian in the restricted sense here specified. The

Allegheny chain, in this sense a separate group of mountains, includes as its extreme south eastern members, the so called Allegheny mountain of Pennsylvania, and its continuations, the eastern front ridge of Virginia, the Greenbrier and Great Flat Top mountains of the same state, and the Cumberland mountain of Tennessee. The ridge delineated on the maps of Virginia, as the Allegheny mountain, is in the central latitudes of that state, a member of the Appalachian chain, to which it shows itself to belong, not merely by its position, but by all its features, both external and geological. Further south in the same state, and in North Carolina, the mountain improperly denominated the Allegheny, is in reality the main axis of a still more eastern chain, which being continuous from Georgia to the Highlands of the Hudson, should receive the general name of the Blue ridge chain. Similar errors in the nomenclature of the Appalachian ridges in Pennsylvania prevail, and produce serious confusion in the topography of that position of our state map, tending greatly to embarrass the geological explorer, and to render an accurate delineation of our formation on the basis of the present map an exceedingly difficult task. All that extensive portion of the state spreading to the west and north of the high table land whose south eastern verge is called the Allegheny mountain, I shall entitle the *Allegheny region*, choosing in this as in other instances, to employ a name previously in use, though modifying in some degree its meaning. The river, Allegheny and its numerous tributaries, water so large a section of this wide undulating plain, which reaches from the escarpment of of the Allegheny mountain to the western and northern boundaries of the state, that the application of its name to the whole region seems peculiarly just and appropriate. Having been fortunately led by the reconnoissance first made, to the above natural classification of the territory of the state, I could not hesitate in deciding to which of these three regions the earlier examinations of the survey ought to be directed. The middle or Appalachian region, contained obviously elements essential to the settlement of many questions of the highest interest and importance, at the commencement of a systematic exploration of the state. Being by far the most mountainous and broken in structure, and possessing also a great variety of strata, the leading problems in our geology were there to be presented for solution; and it was deemed most judicious to grapple at once with the intricacies in the stratification of this region, as promising the readiest clue to the geological relations of the rest of the field before us. Its central position was calculated to facilitate discoveries, in regard to the general resources of the two other regions, and to disclose, simultaneously, all the fundamental points of inquiry, practical and scientific; belonging to whatever portion of the state. Other circumstances of much weight recommend the Appalachian region as the starting point of the survey. In the first place, its including within itself, by far the largest portion of all the richest iron ores; the entire mass of our anthracite coal, and the whole of the bituminous coal district of the Broad Top mountain; and in the second place,of its immediate contiguity to the entire length of the great bituminous coal district, on the northwest of the Allegheny mountain.

Containing so much to enlist directly the private capital and enterprise of our citizens, and to augment indirectly the revenues derived from our public works, this region was thought to hold out special inducements for an immediate examination.

Before entering upon the work of exploring the mineral deposits of this region, and tracing the range and limits of its numerous strata, it was deemed indispensable to the correctness of the results, and to the facility of arranging its dislocated stratification, that a general preliminary comparison should be made between the structure of the different portions of the region, with a view to determine from observation the most expedient quarter in which to commence. The requisite preparatory information was procured by combining with the observations previously made, along the two lines of reconnoissance embracing the portions from Harrisburg to Karthaus; and from Mount Pleasant to Hamiltonsville, other examinations made in previous seasons along the Susquehanna, from Duncan's Island to Northumberland; and in various sections of the Anthracite coal region, as far towards the northeast as the Lehigh and the Lackawanna. On reviewing and comparing the researches made in these several quarters, the advantage of first devoting attention to the south western side of the track, and working thence toward the northeast, was plainly manifest. As a strong geological argument for preserving this course, it may be stated, that in the south western districts of the Appalachian region, from Maryland to the Susquehanna, the formations are in extreme disorder, as if the forces which upheaved and deranged the strata, had acted with their maximum energy in this quarter. Whatever is characteristic, either in the structure, in the stratification, or in the mineral riches of the mountain region, generally, is here exposed under its strongest features; furnishing thereby, on many occasions, a clue to phenomena more faintly developed elsewhere. In this district the strata would appear not only to have been more elevated originally, but to have also suffered a deeper and more extensive denudation than in those portions of the same tract which lie to the northeast of the Susquehanna river, and consequently it is here only, that we find fully exposed, the lower members of the series of strata composing this region. It was thought advisable, for scientific reasons, not necessary to be here detailed, to investigate the older or lower seated formations first; and as from the causes alluded to, they and their mineral contents are brought most largely into view in the south eastern half of the Appalachian chain; this district was selected as the fittest to engage the initiatory labors of the present year.

This area obviously embraces the data for determining the geological positions of each of the three great coal districts of the state, by either including or by passing into their strata; and hence a confident hope was entertained, of being able by the researches of the season to disclose their relations to each other, and to ascertain what situation in the great group of our Pennsylvania rocks, they each occupy.

The facility and precision which have attended each step, in the subsequent development of the stratification of the districts explored, have caused me to be well satisfied with the scheme of research adopted.

Guided by the views here offered; the detailed examination of the Appalachian region was begun in the southern part of Bedford county, and prosecuted during the residue of the season in this, and the rest of the counties between the Maryland state line and the Susquehanna river, in one direction; and the Cumberland Valley and the ridge of the Allegheny mountain, in the other. While exploring this large and interesting district, excursions were occasionally made to the west side of the Allegheny on the one hand, and into the Cumberland Valley on the other, for the purpose of insuring a necessary connexion between the researches of the present year, and those to be carried on hereafter in the two other regions of the state. The' area throughout which this connected series of geological observations has been pursued, embraces by calculation, *six thousand square miles*, more than equaling one half of the territory of Maryland, comprising at the same time, the most mountainous and broken section of Pennsylvania, and as a consequence, the most complex and intricate portion of her geology. In seeking to ascertain the mineral resources of this region, every effort has been made to discover the nature, and to trace the limits of the respective strata by traversing in all directions the mountains, ridges and vallies of the district, in order to mark the relative position of the rocks to each other, their dip and peculiarities of stratification, or to detect the situation within or upon them, of all the useful mineral deposits, especially of iron or coal; and by studying at the same time, every circumstance and fact tending to reveal the mode of their distribution. In the prosecution of these inquiries, the strata were traced both longitudinally and transversely; the mountains and ridges in numerous places crossed, to ascertain their structure and their contents, or to settle doubts in regard to the geography caused by the insufficiency of the state maps. Wherever natural or artificial exposures of the strata were accessible, they were sought, whether laid bare on the steep flanks of the mountains, in crags, cliffs or coves, in the banks or dried channels of the streams, or in excavations on the public works, in mines or in the common pits and wells of the country. From such and other similar sources, familiar to geologists, as the quarters from which they drain this principal knowledge of every district, we have endeavoured to deduce some useful practical conclusions respecting the nature, position and relative abundance of those substances that seemed from their adaptation to the uses of life, to merit an especial share of the labours of the survey.

Aware of the importance of collecting as early as possible, a body of information interesting to the iron trade of the state, a large portion of attention has been expressly directed to the geology of the iron ore of this region. We have therefore visited a large number of the mines and ore banks, besides exploring a multitude of places where ore, not used or not known, was detected and traced by us over the surface. When the observations thus made, shall have been extended to the rest of the state; and confirmed and matured by additional facts; and when the powerful auxiliary of chemical analysis shall have been brought more extensively to bear upon the same inquiries, we shall be able, it is hoped, to submit to the legislature, and in case it should be requested, probably before the final complete report on the survey, a separate view of the present state, and future prospects of the iron manufactured, and iron trade of Pennsylvania, embodying a mass of highly useful practical information.

Besides examining a large number of the known localities, conspicuous or otherwise, of iron ore, coal, and a few other useful substances that occur in the region, many visits of observation were undertaken to neighborhoods, where other minerals were supposed to exist, in consequence of rumours which, on geological grounds, there was every reason to discredit. Traditions, originating sometimes in ignorance, sometimes, probably in fraud, at a period when the nature of the country was but little understood, have filled this section of the state with reputed deposits of lead, zink, copper, tin, nay, of silver itself. Lead ore, in very insignificant amount, sometimes associated with still smaller quantities of an ore of zink, does occur in few instances, but little or no hope is entertained that a workable body of these ores will ever be discovered in this quarter. Very faint appearances of copper have in one or two cases, been met with, but not such as to justify a second thought, while not even the remotest trace of the existence of tin or silver has yet been witnessed by us. Innumerable are the reputed localities of coal, which, upon investigation, were ascertained to be spots occupied by some dark band in one or other of the several slates of the region. Though from increasing knowledge of the stratification of the district, I soon became sceptical in regard to the occurrence of coal in most of these places; it was nevertheless deemed expedient in the elementary stages of the survey, to rest satisfied with no evidence less conclusive than that of actual inspection.

Nothing has exhibited more strongly the propriety of the act providing for a geological and mineralogical survey of the state, than the numerous errors thus disclosed, respecting the *nature* and *distribution* of our mineral resources. Often have your geologists been called on to deplore the infatuation which causes to be neglected, in many neighborhoods, abundant treasures of iron ore, lime, and other materials, fitted to foster a wholesome industry, for the feverish and illusive search after the precious metals. The mineral substance lying between our rocks, or buried beneath our soil, though inexhaustible in their abundance, are very few in kind. In the Appalachian regions, almost the sole varieties conspicuous for usefulness and quantity, are the several species of iron ore and coal, to which we should add the limestone and marl, so serviceable in agriculture, and several kinds of sand stone and clay, applicable in various branches of the manufacturing arts. All these are lavished upon us in a profusion that may fairly vie with what is seen in any other quarter of the continent; and the exhibition of their geological relations opens a field of inquiry, which for usefulness and curious bearing, can scarcely be exceeded in any part of the world. I now submit a brief sketch of the results of the preliminary investigations of this first year of the survey.

Contrary to the opinion often entertained by geologists, that this belt of country which I have denominated the Appalachian region of Pennsylvania, consists chiefly of rocks of the transition class, I may state with confidence, that no conclusion can be better established by the facts now brought to light, than that the whole of the strata of this district, belong to the secondary epoch. This induction is scarcely less important in a practical, ~~than in~~ a scientific point of view. It shows at a glance the nature of the prevailing minerals, and in conjunction with the total absence of igneous rocks in the region, affords a strong presumption against the existence of veins of the more costly metals. Notwithstanding the enormous extent to which the strata are contorted and broken, on no occasion have dykes of trap or porphyry, or veins of quartz, and the other products of igneous or volcanic action, been met with. As these are the usual concomitants of metalliferous regions, except those where certain ores of iron, lead, and of one or two more of the baser metals abound, their absence goes very far to confirm the other evidence collected, of the non-existence here of silver, copper, zinc and tin. The strata of this region belong essentially to that group which in this country is charterized by the profusion of its iron ores, especially of the hematitic and brown ore varieties, referring themselves to that portion of the secondary series, which includes the coal measures, and the group subjacent to these. The Appalachian region so far as it has been hitherto explored, is found to comprise twelve distinct strata or sets of rocks, distinguishable from each other by such strong mineralogical features as to obviate all difficulty in recognising and delineating their boundaries. Dipping sometimes to the southeast and sometimes to the northwest, these strata present numerous great undulations, in consequence of which, some ~~of~~ them, more especially the lower ones, re-appear often, in the space between the Cumberland valley and the coal measures northeast of the Allegheny mountains. For the classification, the most convenient and natural arrangement that offers itself, is a sub-division of the entire series into two systems, grouping together the three upper rocks under the name of the *Carboniferous system*, and the lower nine under that of the *Appalachian system*.

The following is a concise description of these strata, on the ascending order.

1. The lowest in position is a very thick blue lime stone, containing layers of chert or hornstone. It ranges through many of the larger valleys, which are in form, valleys of elevation, whose anticlinal

axes, made by the dipping of the beds in opposite directions, run generally along the centre of the valleys. Resting upon the surface of the rock in the ferruginous soil which covers it, iron ore occurs in great abundance. In the thin veins of calcareous spar which occasionally traverse it, small collections of lead ore have in a few instances been seen. I propose to call this stratum the cove limestone, a name which will serve well enough to designate it until a complete classification and nomenclature of all our rocks can be presented. The blue limestone here described, though the lowest of the twelve rocks which show themselves west of the Cumberland Valley, is not the lowest of the rocks to which it will be necessary to advert hereafter. In that valley, by far the greatest in the state, there exists besides this limestone and the slate which rests above it, another limestone and another slate, both inferior to these in position, but which having no place in the region between the Blue mountain and the Allegheny, are excluded from the series now under consideration.

2. A dark blue, drab colored and yellow slate rests immediately upon the upper beds of the cove lime stone, the darker layers are frequently mistaken for coal shales, but this rock is destitute of the vegetable impressions which generally characterize coal measures, and no coal has ever been found near it in the series. In a few places it contains rich deposits of iron ore, though usually it is not distinguished by an abundance of this mineral. This slate, which I shall call the cove slate, is generally found at the foot of the mountains, in contact with the cove limestone.

3. The next member of the series consists, throughout its lower half, of very hard, tough, greenish and dark grey sand stones, full of mineral specks of brown and red oxide of iron, while the upper portion is an assemblage of very red argillaceous slates, alternating with soft red sandstones. This stratum, containing ferruginous specks similar to those seen in the subjacent greenish beds, though probably one of the chief sources of the iron ore which rests above the cove limestone, is itself rather deficient in that mineral. The usual position of the rock is on the flanks of the mountain, bounding the valleys of the cove limestone, extending generally from near their base to midway up their sides.

4. The fourth rock in order is a white and yellowish white sandstone, moderately fine grained, and remarkable for the pure whiteness, and the hardness and toughness of some of its beds, is the only stratum of the region containing a peculiar tribe of marine vegetable fossil remains, denominated fucoides, which in some of the beds of the stratum occur in great abundance. I propose to characterize it as white fucoidal sandstone. The whitest varieties of the rock appear to be well adapted to the manufacture of glass, China ware, and the finer kinds of pottery. Its ordinary situation is on the external sides and the summits of the mountains which bound the valleys containing the cove limestone, though in some high ridges it dips with both slopes of the mountain and is the only visible rock.

5. To this succeeds a series of beds of very varied aspect and com-

position, consisting in the lower portion of greenish, grey and red shales, passing into argillaceous red sandstone. The middle layers are soft calcareous shales in narrow alternating bands, of nearly every hue, red, yellow, green and purple, blended together as in the rainbow. The upper divisions of the stratum exhibit similar variegated shales, including thin layers of argillaceous limestones, which, as we ascend, grow more abundant and alternate with calcareous shale, having a color passing from grey to dull green. This diversified deposit, ranks next perhaps to the cove limestone in its productiveness in iron ore, some varieties of which are argillaceous and some calcareous. It lies generally on the two sides of the valleys next adjacent to those occupied by the cove limestone. I propose to name it the variegated calcareous shale stratum.

6. The next in the series is an argillaceous blue limestone, having a somewhat slaty fracture, with an easy cleavage in a direction diagonal to the planes of the strata. It contains between its beds thin layers of shale resembling that last described, though these grow less as we ascend, while the rock becomes progressively purer and less argillaceous. It is blue, bluish grey, light grey and black, several varieties of it, especially the two latter, having when broken a strong fœtid smell. The black is sometimes susceptible of a high polish, and would yield a marble somewhat ornamental; some beds are full of organic remains in a fragmentary state. These bear a near analogy to a species of limestone known in England by the name of encrinal marble. The light grey variety is uncommonly soft and has a lustre that may be called slightly silky, from which qualities it has been mistaken for gypsum, though it proves upon analysis to be nearly pure Carbonate of lime.

No decided line of separation can be drawn between these lime stone beds and those of the upper portion of the variegated calcareous shale stratum below them, every feature denoting a gradual passage of the one unto the other. Convenience however dictates this separate classification of them. This stratum is terminated by layers of grey chert; several kinds of argillaceous iron ore occur in considerable quantities connected with this rock, which is likewise occasionally traversed by a net work of sparry veins, containing sometimes small quantities of Galena (sulphuret of lead) and Blende (sulphuret of zinc.) The upper surface of the chert layers, or which is the same thing, the base of the overlying sand stone is a common position for another Iron ore which though sometimes sandy, is frequently of good quality.

7. To the limestone succeeeds a rather coarse grained and loosely cemented sandstone of an impure white and yellowish white colour, and characterized by the abundance of fossils in some of its layers. These are chiefly extinct species of marine shells. Parts of this sandstone resemble strongly certain varieties of the white fucoidal sandstone, the lower portions of the stratum have generally a very coarse texture, are often very calcareous, and contain characteristic fossil shells of unusual magnitude. The softer yellowish variety of this rock is valuable as a building stone, being easy to quarry and to dress,

and not liable to decay from exposure tothe atmosphere. It is likewise the best fitted of all the sandstones of the region, for forming the hearths and inwalls of furnaces. Iron ore of a chesnut brown colour and compact texture is rather abundantly interstratified with the upper beds of this rock, for which I suggest the name of *fossiliferous sandstone.*

8. The next stratum is a dull olive coloured slate, alternating with grey argillaceous sandstones. Towards the upper portion some of the layers consists of a soft very yellow slate, which increases as we ascend, becoming, in the upper part, the principal variety. It alternates with beds which gradually assume a brown and reddish tinge, that grows gradually more distinct, indicating the gentle passage of this rock into the red argillaceous stratum above it. The inferior layers contain occasionally large deposits of a very argillaceous iron ore, approximating in its composition and characters to the argillaceous iron stone of the coal measures. This stratum abounds also in mineral springs, the predominating ingredient of which is sulphuretted hydrogen. It may for convenience sake be called the *olive slate stratum.*

9. Above this slate we find a series of brownish red and buff-coloured slates and argillaceous sand stones, corresponding in nearly every character, except colour, with the olive slates and sandstones beneath. The yellow slate predominating in the upper portion of the sub-jacent stratum, prevails largely throughout the lower part of this, alternating with the red beds, but towards the middle of the mass it gives place entirely to the latter. A few faint traces of iron ore are discoverable in this stratum, though it is for the most part strikingly characterized by a deficiency in this material. The nine rocks here described, constitute a group on which may very properly be conferred the general title of the Appalachian system of strata.—They obviously require to be classified apart from that assemblage of rocks next above them, which is distinguished by every feature as belonging to the coal bearing or carboniferous series. As a group situated low in the secondary series, these nine strata are singularly destitute of indications of coal; whereas no sooner do we pass into the overlying class, than we encounter the peculiar vegetable fossils, and thin flakes of coal associated with other proofs of our having entered the subordinate portion of the great carboniferous system.

I proceed to give the predominant characteristics of the rocks of this latter division. 1. The stratum at the bottom of the carboniferous series, is a group of massive beds of coarse grey sandstone and conglomerate, the sand-stones prevailing most in the lower portion, while towards the top fully developed conglomerates of pure white and partially transparent quartz abound. A somewhat abrupt transition separates this stratum from the red group below. In these conglomerates and sand-stones, we are presented occasionally, not only with the vegetable fossils distinctive of the coal formation, but also with thin scales of coal itself, generally in the form of flattened stems and other portions of the plants found among carboniferous rocks. Instances are not wanting where the coaly deposite, possessing the thickness of a few inches, flatters the hopes of the over sanguine, but is insufficient to entitle the stratum to be considered among the coal measures or productive part of the formation.

Among the results of the researches of the present year, none appears more fully established than that of the absence of any workable seams of coal within the beds of this stratum, which, for the sake of convenient reference, I shall call the lower *carboniferous sand-stone.*

2. A red shale constitutes (where it is present in the series) the next superior member of the carboniferous system. This deposit possesses a remarkably uniform composition, its colour varies from brown to florid red, it is very argillaceous, and towards the lower part of it, occasionally very ferruginous, and contains likewise thin bands of reddish and greenish calcareous rock, approaching in texture and composition, to a moderately pure limestone. A minute quantity of calcareous matter seems to be sometimes a constituent of the rock, imparting to the soil a considerable degree of fertility.

Among its very lowest layers in Trough creek valley, and in several other places bordering the base of the Broad Top mountain, iron ore occurs of unusual density and richness, it lies in tabular masses a few inches thick. The situation of this ore, at the very surface of the subjacent sand-stone, suggests the propriety of seeking for it in the other valleys or coves of similar formation to that of Trough creek, which encircle some of the anthracite coal fields. This red shale stratum, like the sand-stone beneath it, affords a few insignificant traces of carbonized and vegetable fossil remains, indicating its contiguity to coal measures, but not justifying any anticipations of finding workable coal within its layers.

It would seem that this rock is not an invariable member of the carboniferous system, for though distinctly traceable as an independent stratum around the base of the coal field of the Broad Top mountain, and still more conspicuously around the several anthracite coal fields east of the Susquehanna, it has not in its characteristic aspect, been recognized any where skirting the base of the Allegheny coal measures, though possibly it may yet be discovered. As it is thinner beneath the coal measures of the Broad Top than more to the east, where it is associated with the anthracite, it is altogether probable that at the time of its original formation it thinned out and became extinct before reaching towards the northwest as far as the present edge of the coal fields of the Allegheny region.

3. *Coal measures.* The third or uppermost group of beds belonging to the carboniferous system, and the last in order of the whole series of twelve rocks which compose the region between the Cumberland valley and the Allegheny mountain, is the group that embraces all the coal bearing strata of the state. In the anthracite coal region, and bituminous coal tract of Broad Top, the coal measures are to be considered as beginning with the first beds above the red shale stratum, before described, for, not withstanding that the lowest rocks are destitute of coal throughout a thickness of several hundred feet, yet their identity in all respects, with the sand-

stones and conglomerates which alternate with the beds of coal higher up, proves them to be a portion of the same formation.

In the anthracite coal measures, these rocks underlying the lowest coal seam, are an assemblage of massive beds of very hard quartzose conglomerates, from eight hundred to a thousand feet thick. Above these rests a group of numerous seams of anthracite coal, alternating with various coarse and fine grained sand-stones, passing from very silicious and micaceous kinds, to argillaceous varieties, and running by every gradation into grey, greenish, olive-coloured and brown slaty sand-stones, and into dark slates and coal shales. In the lower strata of some of the anthracite coal fields, the seams of coal are in immediate contact with interposed beds of coarse quartzose conglomerate, identical with that which generally lies at the bottom of the series. In the Mahanoy coal tract where this is largely the case, the surface of the coal may be sometimes seen impressed with the rough surface of the conglomerates. This fact is here mentioned to show that dark shales, and argillaceous sand-stones are not, as some suppose, the only rocks indicative of coal. In the district of the Broad Top mountain, the rock at the bottom of the coal measures, is different from that at the base of the anthracite series, and is attended by a corresponding difference in the other portions. It is a coarse, loosely aggregated, greyish-white sand-stone, its thickness below the lowest seam of coal, is much less than that of the unproductive conglomerate underlying the anthracite. Reposing upon it, we find an assemblage of seams of good bituminous coal, interstratified with sand-stones very similar to it, and also with buff coloured yellowish-blue, and brown shales, and argillaceous, slaty sand-stones. There is in this group, and not far from the top of the series in Broad Top, a thin bed of silicious rock, of extremely fine texture, which might be made useful as an oil-stone for sharpening instruments. Thin layers of a light grey silicious limestone, have also been seen in two or three places.

Taken as a group, these coal measures coincide strikingly with those west of the Allegheny mountain; both of them being characterized by a great preponderance of rather coarse, greyish white sandstone.

The chief point of difference seems to be the comparative absence of argillaceous and calcareous strata in the Broad Top series; and a corresponding relative deficiency as far as research has hitherto gone, of the clay iron stone ~~and~~ fire clay, so usual in bituminous coal measures. They are not however altogether wanting; and the coal seams are numerous and of larger dimensions, furnishing several varieties of bituminous coal, finely adapted to either domestic or manfacturing purposes. To enumerate all the subordinate rocks forming the enormous series of coal measures of the Allegheny region of the state, would, even were we furnished with the requisite details, be inconsistent with the scope of the present report. All that I need give, is a general description of such of the rocks as are most prevalent and characteristic. Almost the only rock which meets us at the base of this great group, is a rather coarse, and nearly white sandstone, occurring between the ridge of the Allegheny, and the nearest coal seams northwest. This readily disintegrates into sand, which is nearly pure white. It passes, by a slight admixture of argillaceous matter and oxide of iron, into a light pinkish and also salmon colored variety, which yields, upon decomposition, a sandy yellowish clay. As we ascend in the series, and enter the coal-bearing portion, these sandstones are repeated in great profusion, intermixed with beds which grow rather argillaceous as we pass to still higher strata. In proceeding westward, we witness at the same time an increasing proportion of thinly bedded coal shales, which are frequently bituminous. Associated with these, are layers of fire clay, sometimes imbedding or accompanying layers of nodules of clay-iron stone, and tabular masses of an impure, earthy grey limestone, which is often very argillaceous and ferruginous, having the composition of hydraulic cement. Rising still higher in the strata, thin beds of moderately fine fossiliferous blue limestone show themselves with increasing frequency, while the nodular clay iron ore grows more abundant as we recede from the Allegheny mountain, as far at least as a certain limit, not yet well defined. The above strata variously combined, occur in an almost endless series alternating with innumerable beds of bituminous coal, of a character and composition extremely diversified. It will be seen from the above sketch of our rocks and their order of stratification, that I assign to all the coal measures of the state the same position in the series; placing the anthracite, and likewise the coal of Broad Top, in a position strictly equivalent to that occupied by the carboniferous strata west of the Allegheny mountain. Much contrariety of opinion has heretofore prevailed in regard to the situation of the anthracite; some geologists conceiving it to belong to the so called transition strata; a class lower in position, or of older date than the secondary rocks that contain the bituminous coal. Professor Eaton, from a limited examination made in 1831, of the country adjacent to the Carbondale and Wilkesbarre anthracite coal field, has expressed his conviction of the identity of this coal formation with that of the Allegheny region in Tioga. The grounds of this belief he has not however stated, in a manner sufficiently full and precise to establish the doctrine conclusively among geologists; and, at the outset of the investigations of this year, my own views, though not influenced in any degree by the weaker arguments of the advocates of the opposite opinion, remained, I confess, undecided by any evidence which he had adduced on that subject. I have since been enabled, by comparing my own observations with his descriptions, better to appreciate the nature and extent of his researches, which were, I conceive, sufficient to render highly probable, though by no means certain, the geological identity of the two formations.

The want of positive demonstration upon this point, has arisen from an imperfect classification of the strata beneath both these sets of coal measures. Precise conclusions regarding the comparative age of rocks, can be attained only through a minute examination of their order of super-position; which in this instance I have made with so much care as to obviate, I trust, all future doubts of the close correspondence in position, of our several carboniferous deposits.

The erroneous impressions which existed in reference to the geological epoch of the anthracite, gave birth to precisely similar misconceptions respecting the date of the bituminious coal measures of the Broad Top mountain; for on the assumption that the line of separation between our secondary, and the supposed transition formation of the Appalachian region, followed the south eastern base of the escarpment of the Allegheny mountain, the coal bearing series of Broad Top, was very naturally referred to the same older class, to which the non-bituminous coal had been previously incorrectly attributed. The determination of an identical date, or geological position, between the three several coal formations of Pennsylvania, ought not to be considered as of scientific interest merely; for it is a result fraught with applications of direct utility. By establishing the fact that to a single place in our secondary series of rocks, belong all the several species of coal with which this state is so lavishly supplied; we show the futility of the hope so prevalent throughout the country, of discovering beds of this substance among the inferior slates of the Appalachian region. From New York to Alabama, repeatedly abortive, but unceasing search has been made for coal, among the darker bands of slate rock of the Appalachian system; a portion of our strata too low for that purpose by several thousand feet.

In illustration of the practical importance of an accurate classification, to a perfect under standing of the relative position of our strata; I may allude to the mistake sometimes committed of digging for coal in the conglomerates and sand-stone beds of the stratum, which I have called the lower carboniferous sandstone. In consequence of confounding this rock with the conglomerates and sandstones of the anthracite, which lie two steps above it in the series, a somewhat costly exploration for coal was undertaken a few years since at the end of the ridge called Berry's mountain, where the Susquehanna river passes it. The misapprehension occasioned by the resemblance between the two sets of conglomerates, is likely to be confirmed in the minds of those who look rather to the mere aspect of the rocks, than to their order of stratification, by a corresponding analogy which is found to exist between the red slates underlying one of these strata, and the carboniferous red shale which underlies the other, namely that which is connected with the coal.

That these two red argillaceous strata, have not been hitherto properly discriminated, will appear from the following passage in the useful and generally accurate report on the coal trade of Pennsylvania, submitted by a committee of the Senate in 1834. "The red shale which appears to form the base of the anthracite, and which is found to form a regular and uninterrupted circle or border around each of the deposits, does not terminate east of the river, but continues on either side of Wiconisco creek, and is crossed by the Susquehanna immediately above Millersburg, and also below it *between the Wiconisco and Peter's mountain.*" The inaccuracy consists in supposing the rock in the latter place to be the *red shale*, whereas it is really the *red slate* at the top of the Appalachian system of rocks, and the error if uncorrected is calculated to mislead in any research that may be undertaken, either in the same quarter or in the Broad Top coal district.

In the act providing for the survey, the map of the commonwealth is specified as the basis upon which the areas occupied by the different geological formations of the state, are to be represented. This map, though by far the most accurate that has yet been made of Pennsylvania, is in most portions of its Topography, extremely imperfect, particularly in regard to the delineation of the hills and mountains, the very points in which accuracy is of especial importance in conducting researches preliminary to the construction of a geological map. Innumerable hills and some enormous mountains exist where the geographer has exhibited a level surface, and on the other hand, where nature presents us with a plain, the map would lead us to look for a conspicuous ridge. Instances occur were high ridges are placed on one side of a mountain instead of on the opposite, or in the wrong valley, tending greatly to baffle the best efforts of an explorer, by offering false views of the connexion of the strata. A mountain uniting two others, is sometimes made to join them at the wrong end, and in many cases, ridges naturally connected with each other, are represented as wholly detached. Not only are many of the mountains, and consequently of the valleys erroneously exhibited in their junctions, but they are incorrectly traced in their directions, their shape, and their dimensions also. Scarcely more accurate are the outlines of the streams and roads, while the errors connected with the latter more particularly, occasion the loss of much time, and seriously obstruct the progress of the survey. These numerous imperfections in the map, are to be lamented as producing a two-fold embarrassment to the geologist. In the first place, they greatly impede investigation; and in the second place, they render it impracticable, correctly to lay down in connection with the Topography, the ascertained boundaries of the strata, and the position of their mineral deposits. Let us hope that the legislature will at some future day, remedy these serious defects by authorizing the construction of an improved state map, based upon an exact trigometrical survey.

It may be proper before concluding this report, to indicate the order in which I design to pursue the examination of the formations of the state. The researches of the past season having been chiefly restricted to that portion of the Appalachian region which lies to the southwest of the Susquehanna river, it will be expedient after examining some of the sections hitherto but imperfectly explored, to direct the next investigation towards the north eastern half of the same belt of country, embracing all the anthracite coal measures of the state. The whole range of the great Cumberland valley, so important in an agricultural point of view, and containing besides a portion of the strata of the Appalachian system, seems to demand an early share of attention. Various considerations suggested by the mutual relations of our older strata, and by circumstances in the distribution of their mineral deposits, recommend the south eastern region of the state, as the next field for minute research. While a careful revision of whatever may appear ambiguous in the Appalachian and south eastern regions, which are by far the most intricate in their geological structure and mineralogy, is going on, a detailed survey of the wide and more uniform tracts of the north western or Allegheny region, should be commenced, and the entire strength of the geological corps, devoted as soon as practicable, to their investigation. Upon this plan, it is believed, every portion of the state will receive its due share of examination in the order best calculated to ensure the earliest and most accurate determination of the resources of each. With a view to keep as large a portion of the state as practicable, under general observation, from the commencement of the survey, I shall continue in the subsequent stages of the work, to explore in a comparatively, rapid and cursory manner, certain lines across the districts to which the more detailed operations of the survey may not have yet advanced. This course will be found subservient to many useful ends, by supplying more copious data in the early stages of the survey, for the chemical inquiries connected with it, than could be gathered from a single region, and by affording moreover, much important preliminary information to the geologists previously to the transfer of their investigations to successive new districts. General explorations of this nature, conducted upon a systematic plan, will furnish for each region a species of reconnoissance of the utmost consequence for avoiding subsequent mistakes in its geology, mistakes the more likely to occur, from the vagueness and glaring inaccuracy of many portions of the state map.

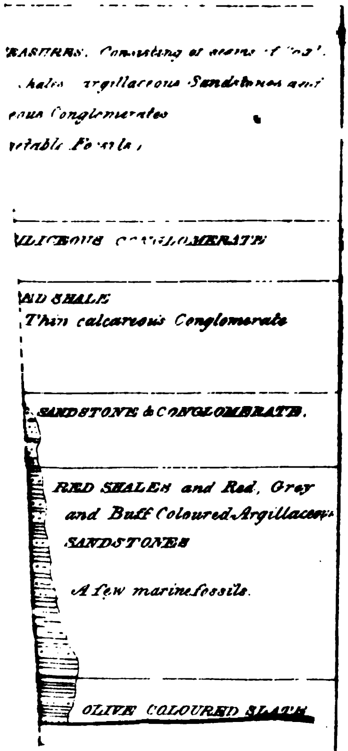
Reviewing the operations of this, the first year of the survey, we are enabled to form a far more precise estimate than was practicable previously, of the magnitude of the investigation; the laborious nature of which is apparent from the intricacy which marks the geology of large portions of the state, the immensity of our deposits of coal and iron both requiring minute attention, and the serious impediments to research growing out of the erroneous delineation of the country upon the state map. A knowledge of the great extent of the explorations to be made, and a wish to unite a desirable celerity with the requisite accuracy and minuteness in the examination, induces me respectfully to urge the expediency of increasing the number of geological assistants. By authorizing the State Geologist to select two additional assistants, and providing for a moderate extension of the sum annually applied to the expenses of the survey, namely, to the amount of two additional salaries, and a small increase to that portion of the appropriation applied to the incidental expenditures, an extent of aid will be contributed of great advantage to the successful completion of the work. With the very small number at present devoted to the exploration of the state, the time which the geological survey must consume, ere it can extend itself to the whole of Pennsylvania, will necessarily exceed the period within which it is desirable to terminate an enterprize fraught so largely with benefit to the state. While the total ultimate cost of the survey will remain the same as if the present hardly adequate assistance be continued, the survey can be completed, it is hoped, in five years from the date of its commencement. Not only will the resources of Pennsylvania be thus earlier made known to its citizens and to the world, but a degree of accuracy and certainty may be attained in the results, to which no period short of one much and inexpediently prolonged, can possibly produce with the present imperfect aid.

All which is respectfully submitted.

HENRY D. ROGERS.

PHILADELPHIA, December 20, 1836.

ON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SANDSTONE & CONGLOMERATE.
RED SHALES and Red, Grey and Buff Coloured Argillaceous SANDSTONES
A few marine fossils.
OLIVE COLOURED SLATE

SECOND ANNUAL REPORT

ON THE

GEOLOGICAL EXPLORATION

OF THE

STATE OF PENNSYLVANIA.

BY

PROF. HENRY D. ROGERS,
STATE GEOLOGIST.

READ IN SENATE, FEB. 1, 1838.

HARRISBURG:
THOMPSON & CLARK, PRINTERS.
....
1838.

SECRETARY'S OFFICE,
Harrisburg, Feb. 1, 1838.

To the Speaker of the Senate:

SIR—In accordance with the acts of Assembly on the subject of a Geological Survey of the State, the Annual Report of the State Geologist has this day been transmitted to the House of Representatives.

I am, Sir,
Very respectfully,
Your ob't serv't,
THO. H. BURROWES,
Secretary of the Commonwealth.

REPORT

OF THE

STATE GEOLOGIST.

To the Secretary of the Commonwealth of Pennsylvania:

SIR—In compliance with my duty, as State Geologist, I respectfully present to the Legislature, the following report of the progress which has been made in the Geological Survey of the State, during the past year.

In my former report, reasons were submitted, somewhat at length, for excluding from my annual narrative of the operations of the survey, any detailed account of the facts ascertained during each season; and for presenting the whole of the results in one mass, at the close of the survey, in the form of a comprehensive and properly matured description of the mineral resources of the State.

Another year's experience in conducting the work, with increased opportunities of intercourse with the people of the Commonwealth, have fully assured me, not only of the discreetness of the course adopted, but of its having met with the cordial acquiescence of our citizens.

I shall, therefore, in the present communication, after mentioning the districts of the State into which the survey has been carried during the past year, give a brief account of the mode of conducting the Geological examinations; and afterwards, offer a short sketch of some of the general results obtained; abstaining, as far as practicable, from introducing, for reasons already before the public, the minute and local descriptions, more appropriate to an advanced stage of the survey.

CHAPTER I.

OF THE SEAT OF THE OPERATIONS OF THE SURVEY.

The last Legislature having amended the act providing for the Geological Survey of the State, by increasing the appropriation, with the view of adding two assistants, and of augmenting the fund set apart for the incidental expenses of the survey, it became my duty to make a new organization of the Geological corps, upon the enlarged scale contemplated. Though solicitous to commence the active operations of the season, with the full complement of assistants authorized by the act, it was found impracticable to embark with any increase of force beyond that of the former year; nor was it until the month of July that, after very diligent inquiry, I succeeded in supplying the survey with assistants of competent talents. The difficulty was, in part, occasioned by some unforeseen resignations, but more particularly, by the extreme scarcity at present felt every where throughout our country, of scientific persons, of accurate knowledge and practical skill in the Geological profession.

I am happy to have it in my power to state, that the survey is now supplied with the whole number of assistants authorized, namely, five; four of whom are aiding me in the Geological duties, and one in the Chemical analysis. Out of the fund designed for the incidental expenses of the survey, I was enabled, during the latter half of the season, to secure the services of four additional aids, who acted in the capacity of sub-assistants; and who, by taking an active part in the collection of specimens, and in the numerous minute measurements required, have promoted, very essentially, the progress of the work.

The four Geological assistants, are Messrs. Samuel S. Haldeman, Alexander M'Kinley, Charles B. Trego, and James D. Whelpley; and the Chemical assistant is my brother, Dr. Robert E. Rogers; all of whom merit a high encomium for the zeal and ability with which they have executed the often arduous duties which I have assigned to them.

The sub-assistants were Messrs. Alfred F. Darley, Edwin Haldeman, Horace Moses, and Peter W. Shaeffer; who, likewise, discharged their duty with much diligence, and a praiseworthy fidelity to the interests of the survey.

Notwithstanding the delay in getting the corps fully organized, it is believed, a large amount of systematic and minute Geological research has been accomplished; for, in consequence of the favorable character of the weather during the past autumn, operations in the field were actively prosecuted until the middle of November—a period later, by several weeks, than that which may occasionally terminate the season.

Through the zealous aid which I have received from the assistants and sub-assistants engaged in the survey, the observations made, during this year, will be ultimately elucidated, by a large and carefully selected series of characteristic specimens of our rocks, coals, ores and other minerals, exceeding, probably, two thousand pieces in number. These are now undergoing a minute examination, and receiving a temporary classification; such of them as require it, being set apart to be chemically analyzed or tested, preparatory to placing the whole collection, when the survey shall be sufficiently advanced, in the State Geological Cabinet.

It was contemplated, in the early part of the season, to explore, in more or less detail, all that portion of Pennsylvania included between the Delaware river, from Easton to the New York line, on one side, and the Susquehanna, from Middletown to Tioga Point, on the other, extending from the South mountain to that part of the Northern boundary of the State embraced between these two rivers. All the anthracite coal regions, and a wide circumjacent country, would have been thus examined. Partly from the difficulty already referred to, of procuring adequate assistance at a sufficiently early period of the season, but more especially from the magnitude of the task itself, it soon became apparent that a portion only of this large territory could be minutely traversed; and this portion was further circumscribed by the time consumed in the detailed measurements, which it became necessary to institute in exploring the several coal fields.

The investigations of the survey have been, during the past season, directed more particularly to the minute features of the several anthracite coal regions included within the general district allotted for examination. The great southern basin, lying chiefly within Schuylkill county, has received the most minute inspection; several portions of it having undergone as thorough an examination as the data supplied by the existing mines rendered practicable at the present time; though much remains yet to be seen before I can draw up a complete account of its resources, and explain the intricate features which these often present.

The most northern anthracite region, that of the Wyoming and Lackawanna valleys, has, in like manner, undergone an extensive series of minute measurements, and has been explored somewhat in detail.

A less minute, though a still considerable degree of attention has been given to that part of the great middle coal region which lies between the head waters of the Little Schuylkill and the Lehigh rivers, including the Beaver Meadow, the Hazleton, and the several neighboring coal fields.

I am gratified to be able to state, that though these researches in the several anthracite districts are, in consequence of the vast multiplicity of the points that needed examination, far from being terminated, they have already resulted in the development of facts of very high practical interest, calculated to lend greater certainty and expedition, in the discovery of coal in numerous new places, and to assist materially, it is hoped, by the sounder views which they may hereafter introduce, concerning the structure of these basins, to the recovery of some of the coal seams, which, from the nature of their dislocations, are daily deceiving the anticipations of the miner.

Much active capital is annually thrown away in our several coal regions, from a want of knowledge on the part of those interested, as to certain features in the structure of particular parts of these basins, which cause many tracts, that are externally promising, to be almost wholly unproductive. The survey, by making the true structure of these districts, better known, has already done something, and will, hereafter, it is believed, when the facts are in a state for publication, effect much more, to check this waste of capital, and give it a more useful direction.

Some valuable and extensive deposits of iron ore, have been explored in the formations external to the coal regions, and such data collected concerning them, as must tend greatly to facilitate the development of the same ores in the corresponding formations in other districts of the State.

Besides the researches undertaken in the various anthracite coal basins, a large extent of country, embracing the several formations below the coal, has been traversed, and in certain tracts minutely explored, where the nature and quantity of particular mineral deposits rendered such close attention necessary.

As many extensive districts, amounting in some counties to nearly their entire surface, possess a very simple, monotonous geology, comprising only one or two well known formations, which were early ascertained to include but few valuable mineral substances, and those in very insignificant quantity, I have deemed it essential to the frugal use of the funds and time of the survey, to exercise a discretion as to the degree of minuteness of the exploration proper to each neighborhood. It is obvious, that some quarters of the State, owing to the amount of their mineral productions, and to the intricate manner in which they are distributed, must require a far larger share of close and detailed investigation, than other regions relatively barren in these resources; at the same time I would remark, that every section of the State will be examined with that degree of scrutiny necessary to determine the absence or existence, and the relative scarcity or abundance of those mineral deposits, which possess a value from their useful applications. I mention this, because disappointment may otherwise be felt at no explorations having yet been made of particular places, containing, or supposed to contain, materials of practical importance. Many such places, within the counties where the survey has been in progress, have not yet been explored; some from a conviction, based on a previous familiarity with the formation, that they do not deserve the time it would require, and some in consequence of the investigations in the particular districts not having yet been terminated. I deem it necessary in Geological researches generally, for the sake of insuring accuracy, and for the avoidance of errors and omissions, that the explorer should revise many portions of his work, and make use of the fresh accessions of more and more, exact knowledge which he is daily acquiring. Upon this principle, numerous districts, which some, who are not familiar with the nature of Geological research, may fancy to have been superficially traversed are designed to be again examined in certain portions, and under far more favorable circumstances, for exactness in the results, than could exist at first, when the materials appropriate to each formation, had not as yet been ascertained.

The following sections of this report, describing the nature of some of the more refined operations of the survey, and a portion of the general results arrived at in the prosecution of the work, will convey a more just idea of the amount of investigation performed, and the degree of detail introduced into it, than could possibly be made known through a mere enumeration of the districts visited and explored.

CHAPTER II.

MODE OF CONDUCTING THE GEOLOGICAL INVESTIGATIONS.

I now proceed to describe, concisely, the manner in which the field operations of the Geological Survey have been conducted. Some brief statements on this subject may operate to dispel certain erroneous notions, which many entertain throughout the State in regard to what is really within the reach of Geological research, and at the same time, inspire a deserved confidence in the precision, the variety and practical value of those results which are attainable.

The legitimate objects of a Geological Survey, the intention of which is general and public utility, should consist, I conceive, in determining :—

First.—The nature of the various rocks comprised in the region explored, and the mineral substances which they enclose.

Secondly.—The extent of country which each species of rock and its associated minerals (or in the technical language, each *formation*) occupies, delineating the limits of every such mineral area on some map of adequate size and accuracy.

Thirdly.—In establishing the order of *superposition*, not only of all the several formations, considering each as a group comprising numerous strata, but also, of the multifarious sub-divisions, or beds composing the respective formations ; ascertaining at the same time, the *thicknesses*, severally, of each individual stratum and group of strata, more especially where there are materials of direct value, such as coal, iron ores, or useful rocks, forming a part of the series.

Fourthly.—In determining, for as great a multitude of places as possible, the angle and direction of the dip, (or slope) of the strata, in order to compute to what depth any known bed or layer descends below the surface in any particular neighborhood.

Fifthly.—In ascertaining, as nearly as possible, the *configuration of the surface*, so as to be able, from observations made on the range, the thickness and the dip of the strata, to calculate, among other results, at what places on the surface, any regular mineral deposits, that we may be tracing, will show themselves.

Sixthly.—In detecting and tracing those contortions, and those abrupt *dislocations* of the strata, which in so many rich mineral districts occur to frustrate the hopes, and to baffle the skill of the industrious miner. An accurate knowledge of these irregularities in the Geological structure of a region, is only to be gathered from an inspection, both extensive and critical, of its mines, and from the features sometimes seen in the exposed portions of its surface. Every person, at all familiar with mining regions, will perceive the incalculable advantage to any disturbed mineral district, of this kind of knowledge regarding it.

SEVENTHLY.—A judiciously conducted survey, must of course include an examination of all those mineral substances, not regularly disposed in strata, but dispersed with less method either in the soil or the solid rocks, which, from their properties and their quantity, promise to be useful to society. The mode of tracing these materials, is more desultory than that where the deposits are regularly stratified; and in the following account of the methods of examination adopted, little will be said regarding this branch of Geological research, as few rules can be laid down to assist investigation, where success depends chiefly on experience, guided by a knowledge of the principles of the science and of the Geology of the particular country to be explored.

In entering upon the detailed investigation of the country included between the Susquehanna and Delaware rivers, which was the principal theatre of the operations of the survey during the past year, a sufficiently correct, general knowledge of the formations of this part of the State had been previously acquired, to render it wholly unnecessary to make, (as was done in the previous season,) any reconnoisance of the region by crossing the country traversely to the range of the strata, a preliminary step of the greatest consequence when the general structure of a district is not already definitely known. A more minute species of exploration was therefore commenced early in the season. A triple sub-division of the whole region being made, the central portion, including all the anthracite tracts of the State, was confided to two of the Geological assistants, but owing to the highly responsible nature of the researches, I devoted by far the largest share of my own personal labors and superintendence to this quarter. To another assistant, was allotted the country laying north-east, and north of the several anthracite coal regions; while the fourth asssistant was charged with the examination of the section included between the South mountain and the Blue mountain. From the comparative intricacy of the Geology of this last division, and from its abundant mineral resources in the shape of iron ores, roofing slates, limestone, and other materials, I bestowed on it, next to the southern anthracite region, the largest proportion of my time and personal study.

The north-eastern and northern counties of the quarter of the State, under investigation, being marked by great uniformity and simplicity of structure, and containing formations relatively less abundantly supplied with useful mineral substances, this division was conceived to claim for the present, a smaller share of my individual attention.

Throughout these several sub-divisions of the State, a very considerable progress has been made, in tracing the boundaries of each of the formations, and in delineating them upon the map.

An ample collection of specimens, illustrating both the more immediately useful, and the scientifically interesting facts in the Geology of the region, was at the same time gathered. Mines, excavations of all kinds, and the natural exposures of the rocks and minerals, were visited and explored, wherever any hope was entertained of their affording an insight into the resources and structure of the country in their neighborhood, in regard to points not previously established.

The various investigations already alluded to, as constituting the inquiries essential to a properly conducted Geological Survey, having been pursued with as much minuteness and method as was practicable amid the impediments arising from the gross defectiveness of the State map, from the wilderness condition of many parts of the regions explored, and the natural intricacy in the Geology of other portions of the country, it is unnecessary to dwell in detail, on all the methods resorted to for collecting the information sought. I deem it quite proper, however, to call attention to the use made, in the operations of this year, of various kinds of surveying instruments, introduced for the purpose of imparting increased accuracy to many of the investigations.

To procure a correct knowledge of the actual position, and the true magnitude of the mineral deposits, as coal, certain kinds of iron ore, and other valuable beds composing part of the strata of any region, it is indispensible, that numerous measurements be performed with the Compass, or what is better, with the Theodolite, the Chain, the Level, and the Barometer, to ascertain the thickness of each formation, and in some cases of each separate stratum.

In performing these measurements, the method is to select some spot, the neighborhood most usually of a stream, where the rocks are sufficiently exposed to display the numerous beds, with their dip or inclination to the horizon, and whatever other important features of stratification they may possess. The more nearly perpendicular to the course of the strata, the general direction is of such natural sections of the rocks, the less is the intricacy of the measurements, and the simpler are the calculations necessary to show the true place and thickness of each bed and formation in the series. It so results, from the peculiar nature of the great subterranean movements which originally elevated our strata, and from the skill of man in constructing avenues of communication among our most rugged hills, that the mountainous districts of Pennsylvania offer the Geologist a remarkable variety of natural and artificial sections, singularly well adapted for supplying accurate data for Geological measurements, and for facilitating the collection of an ample and continuous series of specimens for illustrating our mineral resources. In many cases, a stream passing out of one longitudinal valley to enter another parallel with it, flows through some notch by which the dividing chain of hills, or mountain ridge is cleft to its very base, while, as if to assist still better, the researches of the survey, some road, canal, or railroad, stinted for room, has caused the artificial excavation of the strata, presenting hereby the best conditions possible for accurately studying the rocks and their contents, for securing characteristic specimens, and at the same time, for affording a *base* for measuring the position and dimensions of every thing contained in the formations.

A close examination of our rocks, performed with the aid of instruments, being thus very practicable at a great number of places, it is contemplated to multiply these minute operations of the survey, so as to extend them, not only to all the formations of the Appalachian region, but to many different places in each formation, for which there exists a peculiar facility on account of the re-appearance at the surface of most of the strata, in several successive belts, as we cross the mountain chain of the State. This is likewise promoted by the many natural transverse sections which each formation presents wherever it re-emerges along a ridge or valley of any considerable length. Comparisons may thus be instituted of the highest practical and scientific importance between different portions of the same group of rocks, as seen at various distant points. Thus, should it appear from measurements made of a particular formation in a certain county, that at a given number of feet from the top or bottom, it embraces a regularly stratified bed of iron ore, valued for its excellent properties, it becomes a point of deep interest to ascertain, even with an approximation to accuracy, the distance at which it is likely to be found from the top or bottom of the same formation, should it show itself in other quarters of the State.

The whole stratum, from a number of examinations made at different points, is perhaps observed to undergo, elsewhere, a regular increase or diminution in its thickness; but a chain of such observations will inform us of the *rate* of this change, and enable us to judge, with tolerable precision, of the real situation of the bed of ore, should it still accompany the formation.

Convinced of the correctness of the views here expressed, in regard to the utility of measuring, in detail, the strata at various exposures, I planned and set on foot the instrumental survey of an extensive series of Geological sections, several of which have been elaborately executed, occupying, with the necessary subsidiary explorations, a considerable portion of the latter part of the season.

To present a rapid sketch of what has been done in this branch of research, in the several formations composing the region set apart for the past season's operations, it is proper, first, to mention, that no suitable opportunity presented itself for attempting any detailed measurement of either the *sandstone* formation at the base of the whole series of our secondary rocks, which rests usually on the flanks, and at the foot of the northern ridges of the South mountain, or of the great *Limestone* of the Kittatinny valley, the next stratum in the ascending order.

A minute examination, with the aid of instruments, of the next rock, the *Slate* of the Kittatinny valley, was made on the Delaware river, from a point nearly opposite Columbia to the Water Gap; and the same measurements were extended to embrace a complete section of several of the overlying strata, the sandstones and conglomerates of the Kittatinny mountain, as they are displayed in the majestic cliffs of the Water Gap, and the shales and sandstones of the valley beyond it on the north.

A very extensive section has been begun, but not completed, on the Lehigh, commencing in the neighborhood of Mauch Chunk, with the conglomerate formation, which lies immediately below the coal measures, and embracing all the several groups of strata, so admirably exposed along the river, from that point to the southern side of the bold notch, by which the Lehigh passes through the Kittatinny mountain into the valley to the south. From this line alone, much useful knowledge will be derived. The measurements and the specimens there collected, will show the dimensions and composition in this section of the State, of all the strata, composing no less than nine out of the whole thirteen formations, which constitute the Appalachian region of Pennsylvania.

Another continuous section, including almost as large a number of the formations—eight in all—was measured along the east side of the Susquehanna river, starting from the southern base of the Kittatinny mountain, at the upper surface of the slate, or third formation of the series, and extending through Dauphin to the Third mountain, to the top of the eleventh rock in the series, or the red shale below the coal. A comparison of this section, with those made across the same belt of strata, at points farther east in the State—for example, with that on the Lehigh above spoken of—will present some instructive points of contrast and resemblance.

A highly interesting exposure of the denuded edges of nearly all the middle formations of the series, being exhibited on the western side of the Susquehanna, between Cattawissa and Bloomsburg, and extending by Fishing creek and its little tributary, Hemlock creek, into the heart of Montour's ridge, so as to lay bare nearly every stratum included between the lower part of the Fifth formation and the upper part of the Ninth, a line of measurements was here undertaken.

One principal motive for this, was to ascertain, with precision, the place among the formations of the valuable layer of iron ore, for which the neighborhood in question has become somewhat noted. This section was made to terminate at the junction of Formations No. IX and No. X, at a point near the summit of the Cattawissa mountain; but in order to extend it to embrace the next superior group of rocks, a measurement of these was accomplished where the recent cuttings on the railroad, at its passage through the mountain, in the gorge of the Cattawissa creek, afford unusual facilities for the purpose.

In order, still more fully to establish a clue to the position of the band of iron ore above mentioned, and to ascertain its range and probable quantity, another shorter section, confined to the formation immediately embracing it, was surveyed at a fine exposure of the stratification two and a-half miles below Danville, in the cliffs called the Danville Narrows. The data, furnished by these investigations, will serve, it is hoped, as an index to point out the position of this ore, and the indications by which it must be traced in the other counties of the Appalachian region of the State. The origin, chemical composition, and some of the Geological relations, thus ascertained, of this remarkable variety of iron ore, will be given in an after part of the present report, my object, now, being simply to exhibit the nature of some of the operations of the survey, and the principles and views which induce me to make them an important portion of the work.

In order to make known the true relative situation of the anthracite coal measures of the State, to the other formations which adjoin them, I caused a very complete section to be surveyed, and an ample collection of specimens to be gathered along the Schuylkill river, from near Mount Carbon, through the gaps in the Sharp and Second mountains, to a point within half a mile of Schuylkill Haven. From this section, that on the Lehigh below Mauch Chunk, and that on the Susquehanna near Dauphin, the relations of the anthracite coal measures to the other formations, and of these to each other, will be satisfactorily seen; but until the proper time arrives for delineating them, and the other sections of a similar kind, all of which it is intended hereafter to have engraved, it will be most judicious to omit attempting any minute account of them. With a view to establish, in like manner, the connection between the anthracite coal measures of the Wilkesbarre or Wyoming basin, and the surrounding strata, and also to ascertain in what respects these differ in regard to thickness, composition and mineral constituents, from the strata of the same formations measured at the several points described, on the southern side of the Pottsville basin; a detailed survey was made of the rocks, as they are exposed in the long natural section which the north branch of the Susquehanna displays, in crossing the south-western point of the northern coal field at Beach Grove. Another was undertaken at the gap which the river makes at Nanticoke, and another at the gap of Solomon's creek, near Wilkesbarre.

Within the coal fields themselves, where such detailed measurements of the strata are of special importance for supplying the data by which particular coal seams may be traced and recognized, a number of transverse sections have been surveyed after the same plan. By far the most extensive and elaborate of these, and which has been performed with as much accuracy as the nature of the ground and developments of the region would admit, embraces the entire width of the southern, or Pottsville basin, at its broadest part. This section, which is more than four and a-half miles in length, extends from the Sharp mountain, at Pottsville, to the southern slope of the Broad mountain, in a direction very nearly at right angles to the course or bearing of the strata. Wherever the strata along this line were found exposed by either natural or artificial denudation, measurements were made at right angles to their general bearing, and their dip or inclination carefully ascertained. The distances of the coal beds from certain fixed points, or from one another, were also obtained, either from actual inspection, or from data already in the possession of proprietors.

The same series of rocks and coal beds, whenever it was practicable, were visited and measured in several different places, in order to detect any changes which might occur in their relative thickness, and intervening distances. These measurements were then compared with each other, and the whole finally connected into one system.

In addition to the above labors, the coal mines were personally inspected, and observations recorded regarding the dip, direction, thickness, and the quality of the strata.

Sets of specimens were taken from each coal seam, both of the coal itself, and of its underlying and overlying strata.

Similar measurements, observations, and collections were made along a line crossing the coal region at Tamaqua, on the Little Schuylkill, the investigations here extending to a complete exploration of all the mines that are accessible.

Operations precisely analogous, were performed in that part of the coal basin occupied by the Nesquehoning or Room Run mines, belonging to the Lehigh company; and also, at the vast excavations of coal called the Summit mines, the property of the same corporation.

From the more backward state of development of the western half of the southern coal basin, fewer accurate measurements there were practicable. A transverse section of the basin on Rause creek, north of Pine Grove, was, however, surveyed; while many interesting facts, and valuable data concerning the coal seams and the iron ores of this portion of the region, were procured.

The utility of a series of detailed measurements of our strata, will be obvious, when it is considered, that in conducting such instrumental observations, *all* the rocks and mineral deposits of a district are, in turn, presented to inspection; so that the *true relative place* and *real dimensions* of the most obscure layer, if its nature justify it, may be definitely ascertained. Thus, when the measurements of a formation are sufficiently multiplied, *nothing* that constitutes a part of it, as a regular stratum, however minute, need escape observation; since its place being already known, in relation to that of all the other beds of the group, we are in possession of a clue of the least erring sort, to lead us to its discovery. While this is strictly the case, let it be borne in mind, that the mineral deposits of the earth, unlike its vegetable and animal inhabitants, follow no very constant type—undergoing, though sometimes very gradually, incessant changes, both of composition and external features; so that it behooves us, before we apply, in practice, any supposed clue which our measurements may have afforded us, to assure ourselves, from an adequate number of instrumental observations, performed over a sufficiently wide district, of the nature and amount of the modifications presented by the strata, that we may make the required allowance in our calculations. Yet, this very consideration is itself a striking argument in favor of the importance of accurately measuring our formations; for, if they vary from point to point in their dimensions and aspect, how shall we guard against the liability of confounding one stratum with another, but by subjecting them, at various places, to that critical species of comparison, which we may institute when we know all the dimensions, and have full suites of specimens of the rocks before us? The propriety of this remark is well exemplified in the delusion which many of the citizens of the State are under, respecting the presence of coal in a group of rocks in which it has no existence, situated several stages below the true coal measures, but where some fallacious appearances of a coal formation prevail. Some useful illustrations of the necessity of tracing the variations in the nature and quality of our rocks and minerals, by means of multiplied measurements, and an ample series of specimens, will be offered in a subsequent part of this report.

While the examinations in the field have been thus in active progress, the investigations in the chemical department of the survey, have also been diligently pursued.

A laboratory has been provided, with the requisite apparatus and agents, and an extensive series of Chemical Analysis of the ores, coals, limestones, and other substances of practical importance which had been commenced towards the close of the former season, has been steadily prosecuted during the past year.

TABLE

V.	tain, and on the sides and summit of Montour's ridge.	The lowest layers abound in several species of the marine vegetable fossils called *fucoides*.	least. Delaware Water Gap.
IV.	Kittatinny or Blue mountain.	Hard white and grey sandstones, and coarse massive quartzose conglomerates. Contains impressions of several species of *fucoides*.	1,886 feet. Lehigh Water Gap.
III.	Northern side of the Kittatinny valley.	Dark fissile slates, usually blue, dark grey, black and dingy olive, and sometimes drab, yellow and red. Contains also some beds of sandstone, and a few of conglomerate.	6,000 feet at least. Delaware river, below the Water Gap.
II.	Southern side of the Kittatinny valley.	A blue limestone, with thin interposed layers of chert.	6,000 feet. Not yet ascertained, but probably, as much as stated.
I.	Southern margin of the Kittatinny valley, and northern side of the chain of hills called the South mountain.	A very compact, rather fine grained white and light grey sandstone.	Not ascertained, but probably 1,000 feet.

CHAPTER III.

AN OUTLINE OF THE GEOLOGICAL STRUCTURE AND MINERAL RESOURCES OF THE NORTH-EASTERN HALF OF THE APPALACHIAN REGION OF THE STATE.

The main intention of the present report being to exhibit a correct picture of the progress made in the Geological Survey of the State, during the past year, that purpose would be imperfectly fulfilled, unless I added to the statement, just given of the operations of the season, a brief general description of some of the more obvious Geological features of the regions explored. Such a sketch will serve the two-fold end of rendering more apparent the extent to which the survey has already proceeded in establishing many fundamental points in the geology of the State, and of placing before the reader a few of the results, whose useful applications will justify this early mention of them.

Having extended the investigations of the last season, in greater or less detail, to all the formations lying between the northern base of the South mountain, and the table lands of the Allegheny mountain; and between the Delaware river from Easton to the northern line of the State, and the Susquehanna from Middletown to Northumberland, an opportunity has been afforded of becoming acquainted with the entire series of strata, comprised in this north-eastern half of the Appalachian region of the State.

It will be seen, by an inspection of the opposite table, that there are thirteen distinct groups of strata, or formations, in this portion of Pennsylvania; the lowest reposing on the primary or crystalline rocks of the South mountain, and the uppermost consisting of the materials embracing the anthracite coal.

In my first annual report, referring to the formations occurring between the Kittatinny, or Cumberland valley, and the Allegheny mountain, and lying to the south-west of the Susquehanna, it will be remembered that only twelve were enumerated. But the researches therein mentioned, did not extend to the formations of the Kittatinny valley, on the southern margin of which I have since found that another rock exists, underlying all those previously recognized, which must now be added to the series. A comparison of the temporary classification proposed in the first report, with that now offered, will present a want of agreement in two places. In the first place, the rocks described as third and fourth, in the former series, are now thrown into one formation, and constitute the fourth of the present classification; and in the second place, the thick and conspicuous conglomerate and coarse sandstone rock, which every where underlies both the anthracite and bituminous coal, is made a distinct formation from the coal measures, with which I at first united it.

For the present, I have studiously abstained from framing a nomenclature for the several formations of the extensive system of rocks here enumerated, preferring (until I become entirely familiar with the many modifications, which they undergo in their course through the Appalachian region,) to designate them as well by their numerical position, counting from the bottom of the group, as by distinctive features in the rocks, and a reference to their geographical situation. Until a very wide examination of the strata of our mountain series shall have been made, extending indeed to a comparison between the features they assume in our own and in the adjacent States, through which they range, it would, I conceive, be premature to affix any other names to them than such as may hereafter be readily superseded. While our reseaches are pending, no mode of specifying the strata appears so practically useful, as that which expresses the relative situation of each rock to all the others of the region, and none certainly so free from abiguity, when combined with a reference to their several geographical positions.

FORMATION No. I.

SANDSTONE OF THE SOUTH MOUNTAIN.

In the ascending order, the first formation which we meet with, reposing on the primary rocks of the South mountain, (which is generally the south-eastern limit of the Appalachian region of the State,) is a remarkably compact, and rather fine grained sandstone, usually white, or of some light shade of grey. It consists almost exclusively of nearly pure siliceous sand, held together, it would seem, rather by a simple, intense adhesion of the grains, than by the intervention of any cement. These grains, in some varieties of the rock, consist of nearly transparent quartz; in other instances, numerous black crystalline specks abound, the fragments, apparently, of some of the harder dark minerals of the adjacent primary rocks, from the disintegration of which this formation has evidently derived its materials. Not unfrequently the stratum appears to have undergone a baking from great heat, as shown by the approach to vitrification of the particles, by the fragmentary condition of the whole mass, by the ringing sound of the rock when struck, its splintery fracture, excessive hardness, and sometimes by a manifest discoloration, such as igneous agency is known to cause.

When thus partially altered, this rock is an extremely good material for roads, possessing the requisite durability, and yet on account of its shattered structure, demanding only a very moderate amount of labor to break it up.

The formation ranges, according to my present belief, from the Delaware, at Easton, more or less interruptedly across the State, to the Maryland line, pursuing an undulating, irregular belt, coinciding with the northern and north-western side of the chain of hills most commonly called in this State, the South mountain, the prolongation of the Highlands of New York, and of the Blue Ridge of Maryland and Virginia. Its usual place is at the base and upon the flanks of the hills, which form the immediate boundary on the south-east of the great Kittatinny valley; but owing to the quantity of loose materials lodged at the foot of this chain, this stratum is only occasionally exposed, rendering its exact course through the country difficult to trace and delineate upon the map. It is met with in a few places apart from the range of hills against which it commonly reposes, occurring even at distances of some miles in the Kittitanny valley, having been thrust to the surface through the thick overlying limestone formation by the agency of the vast subterranean forces which once convulsed this whole region. In these cases, it almost invariably gives evidence of having experienced an intense heating.

The formation is to be seen on the northern slope of the hill called Marble mountain, near Easton; also in a ridge about two miles east of Allentown, where it plainly exhibits changes of appearance, resulting from great heat, and a violent, crushing force. It is seen at a point considerably nearer to the same town, where it has been somewhat extensively quarried to supply a building stone for the fine new bridge just erected over the river Lehigh. For such purposes, it would seem to be extremely well adapted, whenever it can be found, as it often is, unchanged by the agency above alluded to. We meet with it again near Metztown; also, in a ridge near Coxtown, and in very regular stratification about three miles from Reading, well exposed by the cuttings on the Philadelphia and Reading Railroad.—Not to attempt at present tracing it in any detail, it may be enough to mention, that it occurs upheaved in a bold ridge at Chicques, on the Susquehanna, a mile and a-half above Columbia, and at many points still further to the south-west—thus it is found in the same range at Ege's iron works, seven miles south of Carlisle, and at the gap of the South mountain, on the Chambersburg and Gettysburg turnpike.

The principal uses to which this rock is applicable, have been already mentioned; but I cannot avoid, in this place, calling attention once more to its fitness as a building stone, the more suitable varieties being sufficiently easy to quarry and to shape, undergoing no action from climate, and possessing, when dressed, a very agreeable light grey aspect.

Notwithstanding the occasional partial vitrification of this rock, at its junction with the primary masses against which it rests, the excessive compactness of structure arising from this source, though a common, is by no means a prevailing character. As soon as we recede from the immediate neighborhood where the igneous agency is unequivocal, we find the sandstones to become less indurated, so that, in many places, its texture adapts it excellently for a building stone.

It contains, as far as yet examined in Pennsylvania, very few organic remains; the best defined species discovered in it being a marine plant, indicative of the oceanic position into which the materials of this stratum were originally swept.

I have satisfied myself that this rock is not confined to the Appalachian region of Pennsylvania, but that it possesses a prodigiously extensive range, not only through Maryland and Virginia, but in a contrary direction through New Jersey and New York, and I believe beyond those limits, constituting every where the lowermost formation of the wide spread secondary strata which it encircles in a somewhat interrupted belt, following the primary boundary of these rocks from Tennessee to Lake Champlain, and thence north-westward to the northern shores of Lake Huron and Lake Superior.

I have undoubtedly recognized it at many points along the chain of the Highlands in New Jersey and New York, and consider it identical with the formation which occurs in the north-eastern part of this latter State, and which was described several years since by Professor Eaton, under the name of "*calciferous sand rock.*" It is the same stratum, I am disposed to believe, which Dr. Bigsby has mentioned, as existing on the northern side of Lake Huron.* My brother, Professor William B. Rogers, in conducting the Geological Survey of Virginia, has discovered the same formation there, resting upon the western slopes of the Blue Ridge, along which he has traced it for a very great distance.

FORMATION No. II.

LIMESTONE OF THE KITTATINNY VALLEY.

The next rock in the ascending order, is the very extensive limestone formation, which occupies the south-eastern half of the Kittatinny valley throughout its entire course across the State.

In its ordinary aspect, this rock is a blue limestone, of a somewhat earthy texture, in general moderately pure, but often containing more or less sand, clay, and oxide of iron, alone or together, in its constitution. Layers of chert, sometimes called flint, are common between its beds. The direct superposition of this formation to the sandstone previously described, is well displayed in the excavation on the Philadelphia and Reading railroad, at the end of the Neversink mountain, three miles from the town of Reading. It may be seen in like manner at Chicques ridge on the Susquehanna.

At its south-eastern margin, or where it borders on the base of the South mountain, its general inclination is towards the north-west, in conformity with the dip of the underlying sandstone; but we seldom recede half a mile into the valley, before a change of the dip to the south-east occurs; and what is not a little strange, this latter direction, though contrary to that into which we might naturally suppose the strata would be tilted, by an upheaving action exerted along the chain of the South mountain, is by far the most prevalent inclination of this rock, throughout its entire range. Between the Delaware and the Schuylkill, there are frequently two, three, or more anticlinal axes, changing the direction of the dip of this limestone, though on its north-western margin, the inclination is towards the north-west, causing it to disappear in regular and orderly arrangement beneath the slate formation that next overlies it. But between the Schuylkill and the Susquehanna, a distance of fifty miles, these two formations observe a contrary or south-eastern dip, along their line of contact, giving rise to the curious phenomenon of an *apparent inversion* of the strata; the slate, which was originally the uppermost rock, seeming to disappear beneath the beds of the limestone, which was originally undermost. From this circumstance, and the many indications of great fracture and contortion observable in the limestone and slate of the Kittatinny valley, it would appear, that these rocks are included in the most convulsed tract in all the Appalachian region of the State.

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* See Transactions of the Geological Society of London.

The upheaving forces which have evidently disturbed the strata in various parts of this vast valley, have in several places thrust the subjacent limestone to the surface, within the district occupied by the slate. This is the case in the small isolated limestone tract on the west side of the Delaware, four miles below the Water Gap, the western termination of a long narrow *valley of elevation*, in which the limestone is brought to view along the Paulinskill in New Jersey.

Another instance of the protrusion of the limestone rock through the slate, exists near Kreidersville, occurring, like the former case, in Northampton county, and a third is on the Little Swatara creek near Jonestown, in Lebanon county.

This truly valuable rock, is applicable to many uses, some of them of the very highest importance to the prosperity of the section of the State possessing it.

In regard to the adaptation of the several varieties of this limestone as a building stone, and to the manufacture of lime for mortar and cements, and for a manure for the soil, some interesting facts will hereafter be submitted, when the results of the numerous chemical analysis, now on hand, are sufficiently matured, to authorize their publication.

Omitting, for the present, the other topics that suggest themselves in regard to this rock, I may mention, as a matter worthy of present attention, the existence of highly ornamental marbles in various places throughout the formation.

Some very beautifully shaded and variegated marbles, capable of receiving a very fine polish, have, in the course of the past year been brought to light in Lancaster county, by some of the inhabitants; and but little doubt is entertained, that quarries may, hereafter, be opened, which will yield slabs and blocks of adequate dimensions, to make these discoveries of considerable importance. It may be of use to mention here, that I consider the limestone formation of the neighbood of the city of Lancaster and the adjacent part of the country, to be the same rock as that which lies to the north-west of the South Mountain in Northampton, Lehigh, Berks, Lebanon and Dauphin; and that, while a fair prospect exists, of meeting with the fine grained white and variagated kinds, that constitute ornamental marble, in the more altered part of the formation, as it ranges through some portions of Lancaster county, yet sufficiently promising localities have already been explored in the other district, to warrant a hope, at least, that marble of more or less excellent quality, may be developed there. But numerous examinations and experiments are requisite to test the value of the specimens gathered, and time has not yet been afforded to enable me to report the results.

Iron Ores of the Kittatinny Valley.

The iron ore connected with the limestone formation of the south-eastern side of the Kittatinny valley, claims strongly our attention, from its amazing quantity, its wide distribution, its generally very excellent quality, and its great accessibility.

Though very variable in external appearance and structure, this ore belongs universally to that species, called by mineralogists, *brown iron ore;* assuming nearly all of its modifications of form and structure. It is sometimes compact, and occasionally possesses a fibrous crystallization, and then is true brown *hematite;* but a more usual structure is, either that of an irregularly cellular mass, or of a concretion composed of numerous parallel cylinders, like icicles or stalactites; in which case, it receives the name of *pipe ore.* In chemical composition it is rather uniform, the more usual impurities being Silica, (the material of common sand,) Alumina, (or the material of pure clay,) and more rarely, Sulphur and Manganese.

The richer kinds may be stated to contain, on an average, from 70 to 80 per cent. of the peroxide of iron, equivalent to more than 50 per cent. of pure iron in the crude ore.

A few descriptive remarks, referring to two or three of the mines will convey a sufficiently correct knowledge of the ordinary conditions under which it occurs.

On the north-western side of the Delaware river, about two and a half miles below Belvidere, a deposit of the ore exists, which is beginning to be somewhat extensively mined. It lies in a yellowish ferruginous clay, amid large detached pieces of limestone; but the diggings have not yet reached the regular strata of that rock. The chief deposit of the ore, occurs about forty feet below the surface. In mining it, shafts are sunk, until the ore is found; after which, the excavation is carried forward horizontally in the ore, which is raised to the surface by a windlass. It consists principally of the porous cellular variety, and of the kind called pipe ore; an impure sandy ochre, and a fine white clay occurs with it.

About five miles north-west of Allentown, and three from the river Lehigh, are large deposits of ore, which have been rather actively worked for the last ten or twelve years. The predominant variety here, is the brown hydrated peroxide of iron, though the red oxide is also abundant. True brown hematite, and a variety of jaspery iron ore, are likewise not uncommon. The material in which the ore is imbedded, is a ferruginous clay, resting over the limestone. A white clay, and an impure ochre, are also associated, as in the case below Belvidere. None of the excavations have yet reached the subjacent rock. The mining is done either by shafts, or when the configuration of the ground permits, by simply quarrying in the open air.

Iron ore is found in moderate abundance, and of excellent quality, in the neighborhood of Emau's, five miles south-west of Allentown; it occurs in clay, no rock being very near it. The ore presents fewer varieties in this place, than at the mines last mentioned.

About a mile and a half west of Trexlerstown, in Lehigh county, in a tract where the surface of the limestone formation is quite level, there is a very large deposit of iron ore; some of which, without altering its external structure, which is that of the cellular and pipe ores, has passed to the condition of sulphuret of iron, or the common *copperas mineral.* This mine was originally worked for the iron ore which it contains, this being still an object of pursuit; but the person conducting it, finding the good ore to be mixed with a large quantity of the sulphuret of iron, referred to me about three years since, to devise a remedy for the injurious effects of that material upon his ore, and was advised to give his attention to it, not as an iron ore, but as a substance well suited for the manufacture of copperas. Since that time, he has sold large quantities of it for this purpose, in Philadelphia, at seven dollars and a-half the ton.

The several layers in this mine, vary much in their dimensions; but their respective average thickness may be stated thus:

Soil,	2 feet.
Brick, clay, and gravel,	25
White clay, pieces of slate, and red clay,	3
Very dark clay,	4
Iron ore and copperas mineral, from 6 to 18 feet,	12
Ferruginous sand,	2
	48 feet.

Generally, the pure iron ore, and the sulphuret of iron or copperas mineral, occur separately, or in different layers of the same stratum, the sulphuret in the lowest position.

The ore is of very good quality, and of several varieties; among these, are the brown hydrated peroxide, having the forms of compact, cellular and columnar or pipe, ore; and the red hydrated peroxide, the structure and forms of which, are no less diversified.

To attempt to specify, in this place, the very numerous localities in which the superficial appearances indicate the probable existence of more or less extensive deposits, or even to enumerate the many excavations, some of which are quite large, where the ore is daily procured, would be incompatible with the scope of the present report. It may not be amiss, however, to mention one or two particulars respecting the manner in which it occurs.

It appears to be a general rule, that by far the largest and most numerous deposits of the ore belong to that half of the limestone belt which is next to the South mountain. This is, however, not without exceptions, a signal instance occurring in the rich ore tract which lies about five miles north of Allentown, and a little west of the Lehigh, and which is but a short distance south of the northern margin of the limestone, at its junction with the slate.

No part of the whole limestone belt of the valley indicates the presence of so large a quantity of iron ore below the soil, as the district which lies a few miles south-west of Allentown, particularly in the vicinity of Trexlerstown. To allude to the circumstances which usually betoken an abundance of this kind of ore, one of the most obvious, would seem to be considerable depth as respects the deposit of ferruginous loam, clay, or other earth, resting on the rocks of the district. This will, of course, be marked by a corresponding evenness of the surface; for where the strata of the limestone are naked of soil in many places, it implies that the covering of earth which contains the ore can no where be deep. Another very essential condition is, that the earth overlying the rocks should have a large amount of the oxide of iron diffused throughout it. This will show itself by its characteristic bright yellow, or yellowish brown color. It must be observed, however, that the existence of a large quantity of oxide of iron in the deeper part of the soil, will, very frequently, not be perceptible in the color of the surface of the ground, being confined to the lower layers, so that much good ore land is often neglected from a want of enterprise to dig sufficiently deep.

The hydrated brown and red iron ores, of the principal limestone tracts of our State, I conceive to have originated almost entirely, from the filtration of water through deposits of soil rather richly impregnated with the particles of the peroxide of iron. This I think is proved, by the peculiar structure of the ore itself, which, not only puts on the form of stalactites and stalagmites, (concretions of carbonate of lime, produced by the dripping of water,) but precisely those slight variations from these forms which ought to arise from the influence of the particular composition of the surrounding material, clay or loam, or sand, in modifying the manner in which the water would filter through the mass, and deposit the ferruginous particles.

The earth containing the ore, I suppose to have been a *sediment* from that mighty mass of waters which evidently once overspread all our formations, and which derived the materials of this deposit, if we judge by their nature, from the subjacent limestone and the contiguous sandstones. Thus we may at once discern why the largest and richest accumulations of iron ore, are on the side of the valley next the base of the South mountain; for all independent Geological evidence concurs to show, that the waters which I imagine to have left this deposit, flowed towards this quarter from the north, while the level of the valley being most depressed on this side, we ought naturally to look here for the deepest collections of the heavy ferruginous sediments in which the iron ore is principally found.

From the details above given of three or four of the ore deposits in Northampton and Lehigh counties, it appears that the richest collections of the mineral are at a considerable depth below the soil. Though in the cases already cited, the ore does not occur in contact with the underlying rock; instances could be brought from other quarters of the State, where rich masses, surrounded by the ferruginous loam or clay, lie in the spaces which often separate the disturbed and uptilted strata of the limestone near its surface. These facts, and the obvious origin of the ore by infiltration, suggest strongly the propriety of oftener seeking low down in the earthy deposit for the mineral, and of endeavoring to ascertain, previously to commencing an excavation, whether the ground possesses that depth which would appear in general to accompany the larger accumulations of this valuable substance.

The earth resting on the limestone of the Kittatinny valley contains, in many places, a variety of clay, admirably adapted for making bricks. The excellence of this brick earth, is owing, in part, to the minutely divided condition, and the quantity of its silica. This, intimately mixed with the argillaceous matter, imparts to the bricks great durability and uniformity of texture, while an adequate proportion of oxide of iron, causes an agreeable and very permanent color. The excellent hue and preservation of the bricks in some of the older houses in Easton, bear testimony to the good quality of the brick earth of that particular neighborhood.

The remarks which I have here made concerning the great limestone formation of the Kittatinny valley, have had more immediate reference to the rock, as it presents itself between the Delaware and Susquehanna rivers, though they are scarcely less appropriate to other portions of its long range through the same extensive valley, which it pursues south-westward through this State, and Maryland and Virginia, and north-eastward through New Jersey and New York, to the St. Lawrence. Throughout this whole course, it preserves invariably, the same relative position to the long chain of mountains by which it is bounded on the south-east. It sometimes occupies nearly the entire width of the great Appalachian valley, but in general, especially to the north-east of the Potomac, it confines itself to the south-eastern side.

From Lake Champlain, the course of the formation is towards the northern shores of Lake Huron, first encircling the elevated region of primary mountains in the north-east quarter of New York, in a broad zone, the northern half of which, passes up the St. Lawrence, while the other approaches, crosses, and again recrosses the Mohawk, passing Trenton Falls, and joining the first belt east of the outlet of Lake Ontario—whence its direction is nearly north-westward to the upper lakes. In all this long line, it accompanies our lowest sandstone, (the "calciferous sand rock" of Eaton,) overlying it, and like it, dipping commonly inwards, from the border of the great basin, along the margin of which it ranges.

This formation is the same as that which, in my first annual report, I called the *Cove limestone*, from its composing a series of valleys in Bedford, Huntingdon and Centre counties, some of which are called coves. But this name has too local a reference, and I propose to drop it, leaving the framing of a nomenclature for our rocks, to a later stage of the survey.

In the Kittatinny valley, in this State, this limestone presents the explorer with very few well preserved organic remains, while it is replete with them at Trenton Falls, in New York, and at several points in Virginia. Its fossils, however, are more abundant in the limestone valleys on the north-western side of our Appalachian region. Well defined bivalve shells and zoophytes, characterize it in Morrison's Cove, Kishicoquillas, Nittanny and Nippenose valleys, and the several other valleys in the quarter of the State where this formation exists.

The largest caves in the Atlantic States, are in this formation; but this is not the place to speak of mere curiosities.

FORMATION No. III.

SLATE OF THE KITTATINNY VALLEY.

Ranging parallel with the great limestone deposit just described, and lying next in order above it, occurs a not less extensive formation of *slate*, usually occupying the north-western half of the Kittatinny valley. These two very thick deposits, throughout their whole course, from the Delaware to the Susquehanna rivers, pass gradually into each other, along their line of contact.

The upper beds of the limestone partake of the structure and composition of the overlying slate, while the lower beds of this rock are not only calcareous, but contain numerous distinct bands of moderately pure limestone. These insulated narrow belts of limestone are subordinate to the slate, along nearly the whole of the central tract of the valley, between the two great rivers; but they are most numerous north of the Tulpehocken creek, in Berks and Lebanon counties.

They constitute an important resource to the agriculture of the slate lands of all this range, in which the soil seems specially to require some assistance from lime, the judicious use of which liberally repays the farmer. These patches of limestone have, as far as time would permit, been carefully traced, and will be ultimately described in detail and delineated on the map. In its ordinary aspect and composition, the slate formation of the Kittatinny valley, which is the third rock in our series, does not differ essentially from the same stratum as it occurs around the margins of the limestone valleys and coves of Bedford, Huntingdon, Centre and Mifflin counties; and which, in allusion to its usual situation, was called, in my last report, the *Cove Slate.* The ordinary colors of the rock, are black, blue, dark grey, blueish grey, dingy olive, drab, and sometimes yellow; but in its range through the western parts of Berks, and across Lebanon, its predominant colors are red, or reddish brown, with interstratified belts of yellow; the whole formation here assuming a considerable resemblance to the red and variegated slates of *Formation* No. V., occurring north-west of the Blue mountain.

The formation, as a whole, varies extremely in the texture of its different strata, some of which are highly fissile slates, admirably adapted to making roofing and writing slates; while others are massive strata of coarse grey sandstone, with some thin beds of conglomerate.

That part of this formation which contains slate adapted to the purposes of commerce, lies in a narrow zone, distant south, from one to three miles from the Kittatinny mountain, running from a point in New Jersey, a few miles east of the Delaware Water Gap, across the Delaware and the Lehigh, to a few miles west of the latter river. It is, however, only in a very limited number of places within this belt, that the rock presents that fortunate union of circumstances which must prevail, to adapt it to be quarried with success. Not only must the rock be sound, uniform, and compact in texture; easy to cleave in one direction, and tough in every other; and free from any bands (called ribbons) containing sulphuret of iron, which cause its rapid decomposition; but it must lie in a manner favorable for being quarried, with a stream of water passing over the stratum, to preserve it moist, and thereby cause it to split with ease and regularity.

These conditions are found very happily combined in the two quarries, which are at present wrought near the Delaware Water

Gap. That on the west side of the Delaware, worked by the Pennsylvania Slate Company, presents some very interesting features. The true stratification of the rock is only detected, here, by the difference in color, caused by numerous very thin layers, of from a few lines to an inch or two in thickness, traversing the rock in lines parallel to each other, and at various distances, not generally exceeding, I believe, two feet. These ribbons denote the direction of the dip of the strata, being seams of a somewhat different composition from the rest of the mass in which they were originally deposited, at frequent intervals. Between each two of these ribbons, the belt of slate is homogeneous, or of uniform texture and composition; but a difference in the quality of the slate on the two sides of one of these thin layers, is quite common.

When we examine a new surface of the slate, the usual and permanent color of which is a dark blueish grey, the hue of these ribbons is nearly black; but on exposure to the atmosphere, they show, after some time, signs of spontaneous decomposition, and display a whitish efflorescence, which indicates that this part of the slate contains the sulphuret of iron.

These ribbons are, therefore, carefully excluded from the slates, when they undergo the operations of cleaving and trimming, in their preparation for the market.

At this quarry, the general dip of the strata, as indicated by that of the ribbons, is towards the west-north-west, at an angle of about thirty degrees; the exact course of the beds being north, thirty-four degrees east. In the same part of the quarry, the dip of the *cleavage planes*, or, in other words, of the slates, is towards the *south*, and at an angle of nearly fifty degrees. There is, however, a dislocation, or *fault*, traversing the quarry. This is a slide of one part of the stratum upon the other, and is from six to twelve inches wide, being filled with white calcareous spar and fragments of slate. That which is of chief importance, is, that the rock below it has not only a different actual dip from the portion of the stratum above it, just alluded to, and a different direction also in the cleavage of the slates, but a different quality in these slates themselves, those beneath being much superior to those over the dislocation. From this lower part of the quarry, nearly all the roofing and writing slates are derived. The best school slates are got from belts that lie directly beneath the sparry seam or fault. The direction of the cleavage planes in this portion of the mass, is nearly horizontal, while the planes of stratification dip towards the north-west, but at a very moderate angle. The discrepancy between the directions of the cleavage planes, above and below the fault, suggests the probability that the dislocation and slide in the stratum took place after the mass had acquired this remarkable tendency to cleave in a direction oblique to the stratification; for, had the cleavage originated subsequently to the disruption of the rock, we ought to find it maintaining the same direction, and observing the same features, on both sides of the fault. These facts, concerning the change in the quality and the position of the slates, caused by the dislocation, indicate how numerous and minute the circumstances are, which must be attended to by those who enter on the business of quarrying this rock. During the past year, 13,500 dozen of school slates have been manufactured at this quarry, and somewhat more than 300 tons of roofing slates; but these amounts would have been much exceeded, had not the general inactivity of commercial business operated to reduce the number of the workmen employed.

About a mile south-east of the quarry just described, another has been opened; but it has not been vigorously wrought. That on the opposite side of the river, in New Jersey, is worked, though rather inactively, notwithstanding the excellent quality of the roofing slates procured in it.

The only other considerable quarry, at present in operation in the slate belt of this part of the State, is the Union slate quarry, about one mile west of the Lehigh, and about seven miles north-west of Allentown. The most remarkable feature here, is the parallelism of the cleavage planes of the slates to the plane of the stratification. The dip is towards the south-south-east, at a somewhat variable angle, averaging 15 degrees. Owing to this coincidence of the cleavage with the stratification, the surface of the slates is apt to be slightly undulated. They are esteemed well adapted for roofing; but being hard, they are not sold for writing slates. The hardness of the rock in this quarry, I attribute to the high temperature originally imparted to it by a mass of intruded quartz, which has entered it from a deep and heated source within the earth. This injected material has heaved up a portion of the strata, into the form of a small anticlinal elevation in the quarry; and has, in other respects, deranged the dip of the rock. In 1836, there were sent from this quarry, by the Lehigh navigation, 500 tons of roofing slate, sold at eleven dollars the ton.

There is a small quarry, which has been occasionally worked, lying about one mile and a-half west of the town of Nazareth. Roofing slate was also formerly procured on the east side of the Lehigh, near Kreidersville, in Northampton county.

It is by no means improbable, that other points, along the same belt of country, would reward diligent search, by presenting eligible situations for quarries. A few such have been seen, during the investigations of the survey; but more examination is required, before any publication of the details would be appropriate.

One fact, of some interest to those who may direct their attention to this slate tract, is, that throughout nearly its whole course, from the Delaware to within a few miles of the Lehigh, the dip of the cleavage surfaces is towards the south-east; and that, too, independently of the many contortions and changes of dip in the strata themselves, of the slate and the adjoining formations.

In the neighborhood of Nazareth, which is on the line dividing the slate from the limestone formation, a material is procured, which answers well the ordinary purposes of *black paint*. This appears to be, simply, a more than usually carbonaceous, black, and soft variety of the slate, occurring near the base of the formation, a little above its contact with the limestone. It occurs, also, further east, on the Bushkill, and has been found, likewise, on the Union canal, in a corresponding situation in the stratum. It requires to be ground in a drug mill, and levigated in troughs, by passing over it a stream of water. Thus prepared, it constitutes, when mixed with oil, a very excellent pigment for the exterior of houses, fences, and other structures exposed to the weather.

Before closing these details, respecting the slate formation of Pennsylvania, two facts, of some practical importance, deserve mention: One is, that this is the *same formation* which, in Oswego county, in the State of New York, furnishes the grindstones for which that section of the country is noted, and which are distributed extensively throughout the Union. These come from near the Salmon river, about ten miles east of the town of Pulaski. The rock is a soft argillaceous sandstone, not unlike many of the softer sandstone beds of the formation, in our own State. At several places in the Kittatinny valley, good grindstones are said, indeed, to have been procured.

It can hardly be doubted, that the farmers, and others residing upon the formation, will find beds of this rock, well adapted for making grindstones, if they will make some enterprising trials. Little skill or experience is necessary, for testing whether the material is suitable.

The other fact that I would suggest, relates to the identity of this formation with that which extends along the Hudson river, from Newburg nearly to Glenn's Falls; and which furnishes a large supply of grey flag stones, not only to the city of New York, where the material is largely used in pavements, but to many other towns, and lately to Philadelphia. Though the strata of this formation, in the Kittatinny valley, are much contorted, and in many places greatly crushed, yet it is obvious, that in so extended a range, numerous quarries of excellent flag stone, and, it is believed, of grindstone rock, might be successfully opened.

These suggestions are now made, from a sense of the importance to our citizens, and to the public works of the State, of calling attention to many materials which we possess in abundance, within our own borders, as the geology of our State plainly shows, but for which we have heretofore been sending to other States, and even to distant countries.

This slate formation of the Kittattinny valley, though it extends in a *single* broad zone, from the Delaware river to the western side of Cumberland county, appears in Franklin county, in two separate and wide belts, which run thence into Virginia. In its course across New Jersey, it divides, in like manner, into two, and sometimes three, parallel ranges, separated by long narrow tracts of the subjacent limestone, which rises to the surface, in the form of one or more anticlinal axes.

Before entering the State of New York, these belts again unite, and constitute a very broad tract, which occupies three-fourths, at least, of the great eastern valley of that State. Along the central and western portions of that valley, our slate formation ranges to a point somewhere east of Lake George; whence, coursing south-westwardly, it shows itself on the Mohawk, for many miles above its mouth, then doubles westward round the ridge of the Little Falls, and extends, in a north-western direction, to the eastern shore of Lake Ontario. In this north-western part of its course, the strata are nearly horizontal, and contain, on the Salmon river, the beds already described as furnishing such an excellent material for grindstones.

In the first annual report on the geological survey of New York, the rocks of this formation occurring in that district, are called "the grey sandstones and shales of the Salmon river."

Time has permitted me to institute, as yet, only a single detailed transverse measurement of the thickness of this formation; the results of which must, for the present, be accepted, as only approximately correct, in consequence of the obscurity of some of the exposures of the stratum. It was made on the west side of the Delaware river, between the bottom of the sandstone of the Kittatinny mountain, (Formation No. IV,) at the Water Gap, and the upper surface of the limestone, (Formation No. II,) exposed above Dill's Ferry. The thickness of Formation No. III, thus ascertained, is 6,102 feet.

FORMATION No. IV.

SANDSTONES AND CONGLOMERATES OF THE KITTATINNY, OR BLUE MOUNTAIN.

Overlying the great slate stratum above described, and dipping conformably with it, we find in the part of the State immediately referred to in the present report, a parallel formation, consisting of heavily bedded sandstones and massive strata of conglomerate, more conspicuous for the features they impart to the scenery, than for any considerable amount of practically useful material hitherto discovered to belong to them. These rocks are embraced in the long, narrow, nearly level, and generally single ridge, called the Kittatinny, or Blue mountain, which stretches continuously from Cumberland county to within a few miles of the Hudson river, near Kingston. They consist of massive strata of hard, white and grey, siliceous sandstones, of various degrees of coarseness, and also of ponderous beds of extremely hard quartzose conglomerate, the pebbles of which are often of great size. The finer grained sandstones abound most in the higher parts of the stratum, and are identical, in general aspect and texture, as indeed the whole of the deposit is, in relative position, with the stratum denominated in my former report, the *white fucoidal sandstone.* The main deposit of conglomerate lies at the base of the tion, resting upon the subjacent slate.

As a group of strata, the whole mass becomes progressively coarser and more varied in composition, as we follow it eastward from the Susquehanna. On the Lehigh and the Delaware, it possesses but little of the fine and even texture, and the whiteness and pure siliceous composition which distinguish this rock as it occurs in the ridges in Bedford and Huntingdon counties, (in Tussey's mountain for example,) some portion of which it retains in the Kittatinny mountain, near the Susquehanna.

Tracing it toward the Delaware, it augments rapidly in thickness; at the Susquehanna this does not exceed about four hundred feet, but at the Water Gap of the Lehigh it is increased to two thousand feet at least.

Mixed with the quartzose sand and pebbles which constitute the principal mass of this rock, we encounter, especially in the coarse conglomerates near the bottom of the stratum, many rounded pebbles and fragments of the three underlying formations which intervene between it and the primary rocks at the bottom of the series. Thus we may recognize some of these pebbles to be derived from the lowest sandstone, some from the dark chert, or flint, so commonly imbedded in the strata of the great limestone of the Kittatinny valley, and others usually less regularly rounded, from the slates and grey sandstones of the extensive slate formation which these conglomerate strata immediately overlie.

Here, then, we have an interesting proof, that the materials composing this deposit were swept together by currents that were set in motion across the three lower formations which now occupy the Kittatinny valley, whose strata were evidently, at the same time, more or less uptilted and crushed.

That great disturbances of the earth marked the period which closed the formation of the slate, and accompanied the production of the overlying conglomerates and sandstones, is apparent from the coarseness of the ingredients in the latter rocks, the promiscuous manner in which they have been swept together, and especially from the suddenness of the transition between the fine grained slate, the sediment of very tranquil waters, and the extremely coarse conglomerate directly in contact with it: the whole aspect of which implies that an enormous mass of sand and gravel derived from strata just broken up, was suddenly strewed into the waters where the slate was forming. But if evidence still more unexceptionable be required, of an upheave of the bed of the ancient ocean, at the epoch immediately preceding the formation of these rocks, we have it strikingly exhibited, at the north-eastern end of the formation, where these conglomerates and sandstones occur on the Delaware and Hudson canal, near the end of the Shawungunk mountain. They are here displayed near Rondout, resting *unconformably* and with a gentle inclination upon the steeply uptilted, contorted, and disrupted strata of the immediately subjacent slate.

To suggest a useful application, which may be made of some of the beds of the Kittatinny conglomerate, and at the same time to prove the importance, when exploring the mineral or geological resources of a region, of embracing as wide a range of observations as possible, I may state, that the somewhat noted Esopus millstones of New York are procured from the formation now before us. The stratum from which they are derived, near the Delaware and Hudson canal, is one of the hard quartzose conglomerates in the Shawungunk mountain, which is the same ridge as the Kittatinny, or Blue mountain of Pennsylvania. There is a probability that in some of the several notches or water gaps of the Kittatinny mountain, a material may be found, as well fitted for making millstones, as the rock at Esopus. The researches hitherto made, regarding this point, indicate a sufficiently reasonable prospect of success to induce me to venture on the present suggestion.

The fourth formation of our series has a very extensive range.—Besides composing the entire mass of the Kittatinny mountain throughout its whole length, from the Hudson river to Cumberland county in our State, it forms the mountains nearly continuous with this range, which bound the Kittatinny valley, (or more appropriately the great *Appalachian valley,*) on the north-west, which extend through Franklin county, Maryland, and the northern part of Virginia, and constitute many of the loftier ridges south-west of the Susquehanna, and between the line of the Kittatinny mountain and the base of the Allegheny. Though it terminates suddenly towards the north-east, within a few miles of the Hudson, which it does not cross, the formation occurs in a district far to the west of this, in the neighborhood of Utica, within a few miles south of which place, the stratum may be seen at several points, cropping to the surface, with a gentle inclination towards the south-west. Here the total thickness of the formation does not probably exceed fifty feet, and yet in composition and appearance, it is identical with the rock, as we behold it in the Kittatinny mountain, near the Water Gap of the Delaware river.

The organic remains preserved in this formation, are very few; those by which the rock can be most readily recognised by an uninitiated observer, are certain species of *fucoides*, an extinct race of marine plants somewhat allied to the modern sea weeds. These are far more rare in the Kittatinny range of the formation than in the other belts of the stratum in the ridges in Bedford, Huntingdon, Centre, Mifflin and Juniata counties. I have, however, seen some broad surfaces of the rock at the Delaware Water Gap, covered by their interlaced and curving stems. This fossil not being confined to the formation under consideration, but abounding even more generally, both in this State and in New York, in the lower beds of the next overlying deposit, I have discarded the name *fucoidal sandstone*, bestowed on it in my former report, as not sufficiently distinctive.

There is a small and very globose bivalve marine shell, a species of *terebratula*, which is occasionally met with in the finer grained sandstone layers, very near the top of the stratum, and which I have seen, as yet, in no other rock of our whole group. As far as organic remains apply, this fossil is very characteristic of the formation.

FORMATION No. V.

RED AND VARIEGATED SANDSTONES AND SHALES OF THE VALLEY NORTH-WEST OF THE KITTATINNY MOUNTAIN, AND OF MONTOUR'S RIDGE.

Resting on the previously described sandstones of the Kittatinny mountain, and occupying a narrow belt of country along the north-western base of that ridge, a formation occurs, some of the characteristics of which are very interesting. This rock, which in my last report I denominated the "variegated calcareous shale formation," when referring to the features which it assumes in the counties of the Appalachian region south-west of the Susquehanna, is composed, where it occurs in the belt next the Kittatinny mountain, of an uniformly red and slightly calcareous shale, and a more or less argillaceous red sandstone. It agrees very nearly in its ingredients, its red colour and other characters, with the lower division of the more variegated belts of the same deposit, which are exposed on the Juniata river; but it is destitute of the many-coloured calcareous shales, and the numerous interposed layers of limestone that occupy the higher part of the mass in that quarter of the State.

These limestone layers have been sought for along the north-western base of the Blue mountain, in that portion of the formation most nearly corresponding to their usual position, but they appear to be absent from this southeastern belt. The valuable, and somewhat remarkable, variety of calcareous iron ore which belongs to several of the tracts of the formation in other sections of the State, has been carefully sought in the same range, on the north side of the Blue mountain, and the conviction has arisen that it also does not occur. A description of this ore will be given, when I come presently to speak of the features of the formation, on the North Branch of the Susquehanna; in the meanwhile, a brief mention of the range of the less important belt before us, will be proper.

It follows the Kittatinny mountain, along a narrow valley, usually not more than a mile wide, and often less, lying between the northern foot of the mountain and a low sandstone ridge, and extends thus from Perry county, nearly to the Delaware Water Gap. Its course thence, is in the same direction across New Jersey and New York, to its termination a few miles south-west of the end of the Shawungunk mountain. It seems there to thin out and disappear, for it certainly does not cross the Hudson.

The red and variegated sandstones described in the first annual report on the Geological Survey of New York, and which underlie nearly all the range of counties running westward, from Oneida county to the Niagara river, belong to the same formation, and bear a very striking resemblance to the strata as they are displayed in our own State.

In the portion of the Appalachian region, north-east of the Susquehanna river, and its West Branch, there are but two zones of this Fifth formation: the south-eastern one, I have spoken of; the other which lies in Columbia county, offers some features to which I now direct attention.

The belt now alluded to, occurs along the northern and southern slopes, and ascends in many places to the summit of a long, narrow and moderately high hill, which bears the name of Montour's ridge, and which, commencing near the West Branch of the Susquehanna, about five miles north of Northumberland, runs nearly due eastward until it meets the bend in the North Branch of the Susquehanna, about two miles below Danville. Thence, after curving for several miles a little to the north, the formation extends, steadily declining in altitude, until its strata sink away in a long and low axis, under the overlying formations, about four miles north-east of the town of Bloomsburg.

Throughout this range, the beds are very regularly upheaved along a certain line, or anticlinal axis, folding over the ridge and resting on its two flanks, with a moderate inclination towards the north and south, rarely exceeding from 15 to 25 degrees.

The lower strata alternate, as they do along the northern base of the Blue mountain, with the uppermost layers of the white and grey sandstones of Formation No. IV. retaining their characteristic chocolate red colour, and distinguished by the profusion of the impressions of *fucoides* upon their surfaces.

In these features they agree with the similarly situated beds, seen at the Lehigh Water Gap, at the Long Narrows on the Juniata below Lewistown, and at various other points throughout the districts where the strata at the base of the formation are exposed.

These may be examined at the southern foot of Montour's ridge, in some deep ravines cut by the streams entering the river near the "Narrows," about two miles below Danville, and in like manner in several places at the gorges of Fishing and Mahoning creeks, in the same ridge.

Above these lower beds, on both sides of the ridge, and also towards its eastern termination, where it is less elevated and steep, there is a rather thick stratum of dull olive coloured and yellowish brown slate, of a more or less sandy texture. Towards its upper part, occur some highly calcareous fossiliferous layers, from a few inches to a foot in thickness, and an interesting bed of iron ore to be presently described. In the upper part of this slate, there are a few calcareous fossiliferous layers, from ten to fifteen inches in thickness, constituting, indeed, a moderately pure limestone, with thin veins of white calcareous spar.

Over these, there reposes a heavy stratum of *red shale*, usually a little calcareous, and also, slightly siliceous in its composition; its ordinary character, however, being that of a thinly laminated and highly argillaceous rock. Its lower portion, includes a few alternating bands of a yellowish green shale, but the upper part is more uniformly red or reddish brown. Towards the top of the stratum, this red shale passes into the next superior formation, (the limestone, which occupies the sixth place in our series,) by numerous layers of dull greenish yellow slates and calcareous shales, which grow more calcareous as they approach the limestone.

The somewhat noted and much prized calcareous *iron ore* of the formation before us, is merely one of the first mentioned calcareous fossiliferous layers, among the particles of which, the peroxide of iron, which has filtered from the adjoining ferruginous bands of the rock, is copiously disseminated, having taken the place, sometimes in part, sometimes entirely of the carbonate of lime of the fossils, which has been dissolved out by the same process that has introduced the oxide of iron. This bed of ore occurs in two lines, one on the northern, the other on the southern slope of Montour's ridge and its prolongation to the east of Bloomsburg, dipping regularly with the other strata, from the anticlinal axis.—Towards the eastern end of their range these two deposits, after converging and sometimes uniting on the top of the ridge, lose themselves under the red shales of the upper portion of the formation, in the vicinity of Espytown, but going westward, they are traceable to a point a little west of Danville. The ore has not yet been discovered, at any considerable distance beyond this point.

The bed varies in thickness from six inches to two feet, and is not more uniform in the proportion of its oxide of iron.

In some places it seems to thin away entirely; in others, the bed divides into smaller layers, which sometimes lose themselves in the contiguous slates. The ore is at present procured in largest quantity from the neighborhood of Hemlock creek, two miles west of Fishing creek, being mined on both sides of the stream, and also on both sides of the anticlinal axis in the northern and southern dipping strata of the ridge. East of Fishing creek, it has not yet been much developed. As far west as Mahoning creek, near Danville, a distance of about twelve miles from Fishing creek, indications of the ore present themselves on both sides of the ridge, though but few excavations have been made in the intermediate tract, owing to the ore here, being more remote from the canal than that on Hemlock and Fishing creeks.

The ore varies materially in different parts of the bed, as respects its hardness, composition, and the proportion of its oxide of iron. The purer specimens consist almost exclusively of the peroxide of iron and the carbonate of lime; these materials presenting the forms and impressions of the various fossils characteristic of the formation.

The siliceous and argillaceous ingredients rarely amount to more than fifteen per cent. of the mass. The carbonate of lime can scarcely be viewed as an impurity, for this material, under some form, usually that of crude limestone, is required in smelting nearly all the ores of iron. In this ore it exists disseminated, and in the most favorable condition of admixture to act as a flux; so that it must be regarded rather as a useful, than a hurtful constituent. It may be stated as a common occurrence, that near the surface of the ground, and for some yards below the immediate out-crop of the bed, the ore, in consequence of the prolonged action of water, trickling through it, and dissolving out its carbonate of lime, is generally soft and of a cellular structure, which is pronounced by those who make use of it to be highly favorable to its ready reduction in the furnace. That which is derived from a greater depth possesses much more compactness, and is both more difficult to be mined, and less rich in iron; and though imbued with a large amount of the carbonate of lime, serving for a flux, it is by virtue of its greater compactness, less easily converted into the metal. The probability is, that by mixing the two varieties and using a copious blast, more economical and productive results will be procured than by employing even the richest kind separately.

In excavating the ore, that nearest the out-crop is reached by removing the covering of earth and slate, to the depth of a few feet, while the portion lying further beneath the surface, is mined by drifts, or levels, entering the bed at points where some cross valley or ravine, gives access to the ends of the strata. The band of ore is penetrated in the direction of its range, or parallel with the course of the stratum in which it lies, with just sufficient deviation from the horizontal line to drain the water from the mine, towards the mouth of the drift. It will become necessary, I apprehend, in order to get access to the ore in some of the middle portions of the belt, when it cannot be reached by the mode of mining just described, to approach it by tunnels perforating the overlying strata. This method, however, will be found much more expensive in the outset than the present plan, by drifts entering at the notches, or depressions in the ridge.

Several points will require to be carefully considered by those who undertake to mine this ore; all of which are embraced in the question, of the depth, beneath its out-crop, to which the stratum may be profitably pursued. Upon this, will depend the value of the belts of land along both slopes of the ridge below the northern and southern out-crops of the ore bed. One consideration, limiting the depth to which it can be advantageously worked, is the increasing hardness of the ore as we descend. Another, is the seemingly progressive reduction in its richness, by reason of the less extensive infiltration of the oxide of iron. And a third, is the increased height through which the ore and the water will require to be lifted, whenever the mines shall be carried below the common water level of the country. The daily growing experience derived from the mining operations now on foot, will tend to multiply the data for making an estimate of the exact extent to which the buried treasures of Montour's ridge can be pursued. Enough is already known respecting the excellent quality of the ore, the large quantity still readily accessible, and the cheapness of the present modes of mining it, to establish a just confidence in the value of this formation as one of the choicest ore tracts in the State.

There are four furnaces which rely on the two or three mines at present in existence on Hemlock creek, for their main supplies of this ore; two are within seven miles of the ore bed, one is at Berwick, within about twenty miles, but convenient to the canal, and the fourth is at Farrandsville, in Lycoming county, to which the mineral is transported on the State canals, a distance of one hundred miles: thus affording a strong proof of the high estimation in which this ore is held.

An average specimen of the porous variety, taken from the out-crop of the north dipping bed, on the west side of Hemlock creek, afforded, on chemical analysis, the following composition:

Analysis of the porous variety of the fossiliferous Iron Ore of Hemlock Creek.

Peroxide of iron, - - - - - - -	85.40 per cent.
Silica, - - - - - - - - -	7.10
Alumina, - - - - - - - -	5.00
Water, - - - - - - - - -	2.10
Lime and carbonic acid,	a mere trace.
	99.60

The proportion of *pure iron*, in this specimen, is very nearly 60 *per cent.*, and it exists almost exclusively in the condition of the Peroxide.

Another specimen selected, as representing the average quality of the ore in the lowest levels opened, taken at a depth of about twenty yards below the out-crop, was in like manner analysed, and exhibits the following results:

Analysis of the compact variety of the fossiliferous Iron Ore of Hemlock Creek.

Peroxide of iron,	61.30 per cent.
Silicia,	2.80
Alumina,	a mere trace.
Lime,	17.84
Carbonic acid,	15.33
Water,	2.20
	99.47

The proportion of *pure iron*, in this specimen, is about 43 *per cent.* the condition in which it exists being that of the Peroxide combined with a small amount of the Protoxide.

With good management, it is found that two tons of the ore on Hemlock creek will yield one ton of excellent cast iron; and I have been informed by a proprietor of one of the furnaces using it, that the result is occasionally even somewhat greater.

A section has been elaborately surveyed from the anticlinal axis in Formation No. V. on Hemlock creek, southward, across it, and the other overlying formations, as far as the Cattawissa mountain.

Another measured in the narrows below Danville, starting from the upper beds of Formation No. IV. in the flank of Montour's ridge, and crossing Formations No. IV. and No. V. will, in conjunction with the first, convey much detailed information respecting the modifications which the strata of this district undergo. They will prove especially useful, by designating the precise position of the iron ore of Formation No. IV. and by exhibiting the character and position of the several rocks, both below and above it; every one of which will thus become, when carefully studied, an index to the same kind of ore in other quarters of the State. Upon this section the vertical thicknesses of the formations are as follows:

From the anticlinal axis on Hemlock creek, to Cattawissa mountain:

FEET.	
304.01	from anticlinal axis to iron ore.
257.68	" iron ore to red shale.
1372.66	" commencement of red shale to limestone No. VI.
1934.35	" anticlinal axis to limestone.
981.56	thickness of limestone No. VI.
4471.59	" of slate, shales and sandstones, No. VIII.
258.48	" of altering beds between No. VIII. and IX.
4172.35	" of shales and sandstones of No. IX.

FORMATION No. VI.

BLUE LIMESTONE ALONG THE NORTHERN BASE OF THE KITTATINNY MOUNTAIN, AND ALONG BOTH SIDES OF MONTOUR'S RIDGE.

The rock which occupies the next place in the series, is a blue limestone. In those tracts where it is fully developed, it consists of several distinct strata, which differ from each other in color and texture, some of them being remarkable for the variety and the profusion of their fossils.

Between the base of this formation and the upper portion of the immediately underlying "red and variegated sandstone" formation, a somewhat gradual mingling of the characters of the two respective rocks takes place, the lower beds of the limestone being usually more or less argillaceous and even slaty, while the upper layers of the lower rock are sometimes highly calcareous, including, in certain districts, regular and well defined deposits of limestone.

The limestone formation now before us occurs in many belts in the south-western half of the Appalachian region of the State. East of the Susquehanna and its West Branch, it shows itself less frequently; the only tracts in this quarter being: first, a thin and obscure stratum, lying usually about one mile north of the Kittatinny or Blue mountain, and stretching from the Swatara creek to the Water Gap of the Delaware river; secondly, a short but broader tract composing the limestone valley of Georgetown, on the eastern bank of the Susquehanna river, in Northumberland county; thirdly, a band which emerges from beneath the overlying strata, about two miles west of Berwick, and there separates into two belts, which encircle Montour's ridge. The most southern of these ranges with a gentle south dip to Bloomsburg, crosses Fishing creek, near its mouth, and afterwards the Susquehanna at Danville. It next re-crosses the river about four miles further west, and thence runs towards the West Branch, which it crosses about four miles north-west of Northumberland. The northern zone, commencing at the same point, west of Berwick, ranges with a moderately gentle northern dip, (following usually the course of a valley,) along the northern base of Montour's ridge. It passes a few hundred feet to the south of Mooresburg, and thence reaches the low grounds above the mouth of Chilisquaque creek, where, like the former belt, it crosses the West Branch of the Susquehanna.

Besides these several zones of the limestone, all of which have been under careful examination, there are others which also lie east of the West Branch, but which are further to the north, and have not been yet explored.

That each of the belts mentioned, consists of one continuous stratum, is placed beyond a doubt, by the circumstance, that though often concealed for a mile or more in length by the loose materials of the adjacent ridges, or by a deep alluvial covering near the streams, we seldom fail to trace the rock, either by the fragments on the surface, or by the solid strata themselves, wherever any transverse valley or ravine crosses the ridges at the base of which the limestone usually ranges. It is equally obvious that all these several ranges are but different out-crops of one widely extended formation; for, in every case, the limestone occupies precisely the same position in the general series of our strata, always resting upon the shales of Formation No. V.

An interesting and important general fact, concerning this limestone stratum, is its increase of thickness at each successive re-appearance, as we recede from the Blue mountain. going towards the north-west. In the south-eastern belt, or that which follows the north-western base of the mountain, its thickness probably no where exceeds one hundred feet; and it would be nearer the truth to state its average dimensions at *from forty to fifty feet.* A careful search on the Susquehanna river, and for many miles east of it, in the range of country where, if it exist at all, it ought to show itself, has served to establish the fact of the total absence of this stratum for many miles along the foot of the Blue mountain, but guided by a knowledge of the position which it should occupy, in relation to the other strata, I succeeded in finding it immediately north of the gap of the Swatara creek. Though, at this point, it is not more than from twenty to thirty feet thick, and quite impure, from the amount of argillaceous matter in it; yet it is convertible into lime, and will prove a real benefit to the agriculture of the immediate neighborhood. An accurate clue to the position of the stratum being once established, its development, at various other points, east of the Swatara, soon followed! and I am now enabled to announce my belief, that this limestone may be detected from the Swatara creek to the Delaware river, at almost every cross ravine or valley, which intersects the base of the sandstone ridge next north of the Blue mountain. Near the Swatara, this hill is called Swope's ridge, but it takes several names in different parts of its course, which is not much interrupted from the Susquehanna to the Delaware. The place of the limestone is usually near its southern base; though, at a few points between the Little Schuylkill and the Lehigh, and also between the Wind Gap and the Delaware river, it occasionally rises to the summit, and even overlaps it on both sides.

The formation evidently augments in thickness as we advance eastward towards the Lehigh, though, between the Wind Gap and the Water Gap of the Delaware, in its prolongation by the northern side of Cherry valley, it gives signs of again diminishing and becoming impure and slaty. It is very thin and decidedly argillaceous where it occurs a few miles south of Stroudsburg. North-east of the Delaware Water Gap, we have not succeeded in tracing it far, and there would seem to be a strong probability that it does not continue more than a very few miles in that direction, as the belt of country which ought to contain it, in Sussex county, New Jersey, has been more than once explored.

Another limestone, very analogous in its general aspect, and in some of its fossils, but much thicker, and occupying a somewhat superior position in the series, commences not far from the Water Gap, and of course near the termination of the former, and ranges extensively towards the north-east, holding the same relative position to the Kittatinny mountain. It is important that we should not confound these two calcareous formations.

It would be entering too far into details, to mention, in the present report, the numerous points where the limestone stratum constituting Formation No. VI, has already been detected, along the several ranges whose general course I have described. I have deemed it of use, thus to draw attention to the regularity with which it ranges, that those who are disposed to convert it into a fertilizer of their soils, or employ it as a flux in their furnaces, may, by a knowledge of its exact relative position to the other strata, readily obtain it.

It may be of service to state, that, as a general rule, the lower beds of this limestone, where it adjoins the subjacent red and variegated shales, afford a lime, in which the chief impurities are clay and oxide of iron; while the upper strata, being contiguous to an overlying sandstone, yield a material more or less sandy. Thus, it is often practicable, with very little difficulty, to select such portions of the formation for quarrying, that the quality of the lime shall be adapted to the peculiar nature of the soil which it is intended to fertilize, or of the ore which is designed to flux. The two belts of this limestone ranging along the sides of Montour's ridge, and thence nearly to Berwick, are the only ones to be found for many miles north or south; and lying, as they do, near to the North Branch canal, they furnish a source of lime, of great importance to a long and wide tract of country, embracing the Wyoming valley.

Iron ore would appear to prevail, very generally, in the soil covering this limestone. It possesses all the characters of the ore which I have mentioned in my former report, as belonging to the same formation, in its various belts throughout the counties lying south-west of the Susquehanna, in the Appalachian district. Thus, it occurs in some abundance at Bittenbender's, five and a-half miles south-west of Stroudsburg, and exists, also, though not yet found in much quantity, near the western end of Montour's ridge.

This ore is, almost invariably, of a light brown, approaching to a chesnut color, and has a uniform, compact, and rather argillaceous texture. Having examined it at a great number of points, on both sides of the Susquehanna river, it is yet doubtful whether it occurs in sufficient amount, at any one place along the limestone belts described in this report, to become extensively useful.

About three or four miles north-east of Northumberland, a deposit of *bog iron ore* occurs, connected, apparently, with this formation. Though the excavation has not yet proceeded far enough to determine its actual thickness, the superficial extent has been proved to be considerable; and should it, on trial, be found to make good iron, it may become very useful for mixing with the rich calcareous ore of Montour's ridge.

Though this formation, and, as I shall presently show, the sandstone which overlies it, terminate towards the north-east, near the Water Gap of the Delaware, they both occur in numerous interesting ranges, extending, in the opposite direction, as far as the interior of Virginia, and probably beyond.

From measurements made on Fishing creek, across that belt of the limestone which ranges along the southern side of Montour's ridge, its thickness at that place is 900 feet, very nearly.

FORMATION No. VII.

SANDSTONE OF THE FIRST RIDGE NORTH OF THE KITTATINNY MOUNTAIN.

The rock which comes next in order in the series, overlying the limestone just described, is a white and yellowish white sandstone, which, in its ordinary aspect, especially in the lower beds, is a coarse and rather loosely cemented aggregate of nearly pure siliceous sand. In the layers next to the limestone, when that formation is present, the composition of the rock is slightly calcareous, as shown by the mode in which the weather acts upon it.

Its most characteristic feature is an abundance of definitely formed cavities, which are the hollow moulds of various kinds of fossil shells, and other organic remains, which have, at one time, existed in this sandstone, but which the porous structure of the rock has enabled the water, long since, to dissolve and carry away. These easily recognized pits occur only in certain beds, and are not equally plenty in every portion of its extensive range. They are not as numerous, in proportion to the thickness of the stratum in the belt which lies immediately north of the Blue mountain, as in some of the other tracts further towards the north-west.

Contrary to the rule observed by the underlying limestone, in passing through its gradations of thickness, this sandstone appears to be most massive in the belt nearest to the Kittatinny mountain; or, more properly, in the south-western portion of it, near the Susquehanna river. In the ridge which crosses the river about half a mile north of the Blue mountain, its strata are well exposed for examination and measurement, being in a nearly vertical attitude. Their thickness, at this point, is about 700 feet. In this quarter, the rock is more compact, and of a greyer color, and a closer and finer texture than in most of the other districts; and it contains fewer fossil impressions. These, however, are not entirely absent, but exist, though sparsely, in certain layers, which as usual, are among the coarsest in the formation. Tracing it eastward, we find it in Swope's hill, near the Swatara, greatly reduced in thickness, and possessing its ordinary texture and aspect. In some of the beds south of Pine Grove, the rock encloses a multitude of the hollow pits, attributable to various species of marine remains, some of the distinctive features in whose structure are easily discernible. In its course towards the north-east, the out crop of this rock, except when cut down to the common surface by some denuding action, occupies, invariably, a steep and ragged ridge, distant from half a mile to more than a mile from the Blue mountain. Extending towards the Delaware, with a slowly diminishing thickness, it seems to vanish entirely before reaching the Walpack bend of the Delaware river, about sixteen miles above the Water Gap.

In several parts of this range, especially those adjacent to the Delaware, the lower portion of the formation, near its contact with the underlying limestone, contains thin layers of *chert* or flint, such as form a constant feature in the belts of the stratum more remote from the Blue mountain, particularly in the counties south-west of the Susquehanna. On the Lehigh, and also near the Delaware, a a similar rather thick bed of chert rests upon the upper side of the stratum, lying along the north-western base of the sandstone ridge.

The materials of this formation, though susceptible of few useful applications, are well adapted to various architectural purposes. Some of the strata not only furnish an excellent common building stone, but, being massive, and readily quarried and dressed, they are much used in the construction of the canal locks on the Juniata.

One variety of the rock, recognized by its porous structure, its coarse and uniform texture, and its pure siliceous composition, seems to be well suited for the hearths and in-walls of furnaces; its only imperfections as a hearth-stone, being the difficulty, sometimes encountered, of getting it in masses of sufficient size.

This sandstone formation, with its accompanying chert, borders the little valley of Georgetown, on the Susquehanna, on the north and south sides, in two converging belts. Though the stratum is here much thinner than in the range next to the Blue mountain, its dimensions are nevertheless considerable.

It is evident, that only obscure traces of the formation occur on the northern and southern sides of Montour's ridge, where, if it possessed any conspicuous thickness, it could not fail to be distinctly recognized in some of the many transverse valleys which expose the strata in that anticlinal axis.

Occasionally, loose fragments of it are seen on the surface, near the range of each of the limestone belts of that neighborhood; and from the very sandy character of the soil along the same line, it is not improbable that a thin, and perhaps continuous zone of this sandstone, may rest in contact with the limestone, having been, from its easily crumbled nature, worn down and covered by loose materials, to a greater depth than the other harder formations adjoining.

FORMATION No. VIII.

THE OLIVE COLORED SLATE OF THE VALLEY BETWEEN THE KITTATINNY AND SECOND MOUNTAINS.

The formation which next presents itself in the ascending order is remarkable for being one of the most widely diffused of all the strata of the Appalachian region, and for the constancy with which it preserves, over a very wide area, the marked peculiarities of its structure, color, and composition. In the counties especially referred to in the present report; it consists chiefly of an extensive series of alternating strata, of dark grey, greenish and olive colored slates, and soft grey argillaceous sandstones. The lowest beds consist of a nearly black, easily divisible and somewhat calcareous slate, while the grey sandstones abound most in the higher parts of the mass. These upper layers, composed of slates and sandstones in frequent alternation, and in nearly equal quantity, gradually become, as we ascend, first brown and then red, until we cease to distinguish them from the lower beds of the great red slate and sandstone formation immediately above.

All the several varieties of this rock, its slates, sandstones, and especially its limestones, where these latter exist, are conspicuous for the profusion of the interesting fossils contained in some of their beds. The whole stratum is more or less calcareous ; and this circumstance, together with the quiet condition which appears to have prevailed in the waters, during the deposition of this very thick formation, may explain the abundance and variety of the organic remains.

This formation occurs, in several very long belts, in the region east of the main stream of the Susquehanna, and of its West Branch. The most southern range, tracing it from this river eastward, occupies the central part of the valley, between the Blue mountain and the Second or Mahoning mountain, as far as the latter ridge extends, which is to the Lehigh river. Thence, in a somewhat broader zone, it pursues the same general course between the Blue mountain and the base of the Pokono, until it meets the Delaware river, immediately above the Water Gap. From this point it follows the valley of the same river, the widest part of the belt being on the north-western or Pennsylvania side, and leaves our State at Carpenter's Point, to sweep, in a long curving tract, entirely across New York.

Between the Schuylkill river and the Easton and Wilkesbarre turnpike, the belt is generally double ; a long and narrow zone of the overlying red sandstone beds of Formation No. IX, lying in a trough in the middle of the Mahoning and Fire Line hills, between the northern and southern ranges of the formation.

This Olive Slate formation occurs again, in a tract of the form of a long and narrow triangle, in the northern part of Dauphin county, extending eastward from the Susquehanna at Halifax, and contracting to a point towards the sources of Armstrong's creek.

It occupies a considerably larger tract, of a somewhat similar triangular shape, in the southern part of Northumberland county, enclosing the limestone valley of Georgetown on its western side, next the river, and narrowing to a point near Zimmermanstown, in Schuylkill county. Opposite Selinsgrove, another long and wide range of Formation No. VIII, encloses another area of the same limestone formation and stretches eastward through the Shamokin and Roaring creek valleys, to within about two miles of the ridges which unite the Cattawissa and Little mountains. It also extends, in a still larger and broader double zone, along the valley of the North Branch of the Susquehanna, from its mouth to the mouth of the Wapwallopen creek, the valley of which stream it thence ascends nearly to its source. The western half of this tract is double, being divided by the long and narrow range of the formations of Montour's ridge, and their continuation eastward to near Berwick. From Montour's ridge, northward, to within about two miles of the foot of the Allegheny mountain, a large portion of the country on the eastern side of the West Branch, is composed of this formation, where its strata are finely displayed in the passage of the river through the Muncy hills. The great width which this range of the formation exhibits, in Columbia and Lycoming counties, is much reduced, after it enters Luzerne, where, following its usual northeastward course, it passes between the Shickshinny and the Allegheny mountains, and tapers to a point somewhere east of Harvey's Lake. Another belt of the same rock skirts, in many places, the northern border of our State, ranging in a nearly east and west direction, and rarely spreading itself more than a few miles to the south of the Pennsylvania and New York line. It is displayed at the Big Bend of the Susquehanna, where it presents all its distinctive features.

The more obviously useful materials derivable from this Olive Slate formation, are, as far as regards Pennsylvania, rather few; and these occur in relatively inconsiderable quantities. In regard to the *ores of iron*, both it and the several overlying formations, as high in the series as the conglomerate beneath the coal measures, are singularly deficient. In Perry county, near Bloomfield, it does indeed contain a very excellent variety of iron ore, and in considerable abundance. But the circumstances which seem to have given origin to it, at that place, are somewhat peculiar; and hence, this mineral is not to be regarded as generally occurring in the formation. Should the rock elsewhere occur in similar topographical relations to the other underlying strata, similar deposits of the ore will probably be found, which a more detailed examination of some parts of the stratum not yet explored, may possibly bring to light.

Some of the layers of this rock, from a resemblance in their colour to the shales of our coal measures, and from their containing at times sufficient carbonaceous matter, to cause their partial ignition, when highly heated, are very frequently mistaken by those who are ignorant of the true relations of our coal bearing rocks, for unequivocal indications of anthracite or bituminous coal. These delusive appearances occur at the Big Bend of the Susquehanna.

No formation of our whole series, has seduced so great a number of persons into abortive explorations after coal. It may be useful, therefore, to embrace this occasion to state, that I feel satisfied that the formation, wide as is its range, contains no coal, in any part of the United States, and that in Pennsylvania it occurs, by calculation, at a depth rarely less than 8,000 feet below the lowest coal seams of any of our coal regions.

This formation is commonly more or less calcareous, and embraces, occasionally, very thin, though impure layers of limestone, in general, only a few inches, or at most, two or three feet in thickness.

One of these layers ranges, rather interruptedly, from Pine Grove across the Schuylkill, and past Orwigsburg, to near Lehighton, on the Lehigh. Another is seen a little south of the ridge bounding the limestone (Formation No. VI.) of the Georgetown valley, on the southern side. A third small bed may be recognized among the strata exposed on the Shamokin creek, in its passage along the base of the Shamokin hills. With particular care in the calcination, the limestone of some of these bands may be converted into a rather inferior kind of lime; though, with a few exceptions, the poor quality and insignificant quantity of this stratum, will not authorize much expense in the attempt.

On the northern branch of the Apollacan creek, there is a hill of considerable elevation, rising on the north side of the stream, and over which the State line crosses. Nearly on the summit of this hill, though rather on the northern declivity, within less than half a mile of the State line, and about a mile and a half from the line of Bradford county, a considerable deposit of limestone occurs, which promises to be very useful to the surrounding neighborhood, as lime is an article much wanted in this region.

It appears to be a mere enlargement of a calcareous band, in No. VIII, covering an area of fifty or sixty rods in length, and six or eight in breadth, having cross joints, and being easily quarried. It does not seem to be a very pure carbonate of lime, but is rather siliceous and somewhat ferruginous; and when burned, will yield an indifferent lime, of a grey or reddish colour, though for building and agricultural purposes, it will probably be found highly useful in a region where hitherto the lime used, has been obtained from a great distance.

Some parts of this formation, particularly the greenish or olive colored slates, would seem to contain a small quantity of the oxide of manganese; and accordingly, where the mountain streams traverse a sufficient surface of these strata, the oxide of manganese, by the disintegration of the rocks, is not unfrequently found in the form of a black, heavy powder, in the beds of the rivulets, where it may sometimes be collected in adequate quantity to render it an article of commerce. The oxide of manganese, from this source, can rarely be wholly separated from the earthy impurities with which it is mingled; and hence, as well as from the very low price of the drug, procured so very cheaply as it is, from the mines of Europe, it can rarely justify much expense in collecting it. This oxide of manganese is tolerably abundant near Dr. Ball's, about four miles north-east of Milford, in Pike county, and at other places in the same region.

Near the base of the olive slate formation, there exists a very interesting and important limestone stratum, stretching over a great range of country, from near the Delaware Water Gap, where it first obscurely shows itself, to the Helderburg mountains, south-west of Albany, and thence by a wide sweep to the westward, across New York to the Falls of Niagara.

From near the Water Gap, this calcareous rock keeps the Pennsylvania side of the river, to the Walpack Bend on the Delaware, where it crosses into New Jersey, which it traverses in the same north-eastern direction, as far as Carpenter's Point. Throughout all this part of the belt, the limestone is accessible from either side of the river, and it is to be lamented, that so little of the rock is converted into lime by our farmers of Pike and Monroe counties.

This limestone deposit is a source of incalculable benefit to the highly fertile counties in the middle and western parts of New York, through which State it passes in a broad zone, generally bordering the Erie canal upon the south. Its lower strata furnish the valuable beds of *Plaster of Paris*, (or Gypsum,) found at Manlius, Syracuse, Tonewanta creek, and various other places; and from nearly the same part of the deposit, is derived an inexhaustible supply of *hydraulic cement.*

Besides these useful materials, the pure limestone beds in the upper portions of the stratum, produce some of the best building stones of that State.

These facts are here briefly announced, because they suggest to us some highly important inquiries, in reference to that portion of the formation which enters Pennsylvania, or closely approaches it in passing down the New Jersey side of the Delaware. Have we within our State, or at an accessible distance, the beds of gypsum and cement which characterize this formation on the Erie canal? As well as I have yet been able to ascertain, the gypsum deposits would appear not to occur as adjacent even as the Helderberg hills, in New York.

The great limestone stratum of the middle and western counties of New York, being a member of our olive slate rocks, or Formation No. VIII, of the Pennsylvania series, its lower beds partake of the composition of this slate stratum; some of the beds of which, of greater or less thickness, generally lie beneath it. But the olive slate is, in many parts of the formation, conspicuous for the large amount of the sulphuret of iron in its composition, (having, from this character, been termed by Professor EATON, who first described it in New York,) "*Pyritiferous Slate.*"

In accordance with some views of the origin of gypsum, occurring under analagous circumstances in Virginia, first brought to my attention by my brother, Professor W. B. ROGERS, we may conceive a chemical re-action to take place naturally, between the oxygen of the air contained in the water, which penetrates the strata, and the sulphuret of iron of the slate, and the carbonate of lime of the alternating calcareous beds. By well known chemical affinities, sulphuric acid will be developed, and a union will ensue between this and the lime, forming the sulphuret of lime, or gypsum.

The rain water filtering through the strata, and carrying down in solution the carbonate of lime, to distribute it ultimately through the layers of the shale, must greatly promote the process; but it is by no means improbable, that the two ingredients, furnishing the gypsum, have been, to a considerable extent, deposited together originally, so that the production of this substance may have commenced at a very early epoch.

From the Helderberg hills to the Delaware Water Gap, there would seem to be an absence of this close association of the carbonate of lime, and the sulphuret of iron in the formation; for there is no series of alternating beds of the shale and the calcareous rock, such as we witness near Syracuse, and other places in New York. This I have ascertained, by examining the base of the limestone formation on the Rondout creek, near the Hudson; and again, in many places in New Jersey, pursuing it from Carpenter's Point, by Milford, to the Walpack Bend of the Delaware, and thence into

Pennsylvania, and along the same line of strata to the Delaware Water Gap.

Nevertheless, I would not wholly discourage a search for gypseous deposits in the belt of this formation, which ranges along the south-eastern side of Monroe county; for, though I have but faint hopes of its existence, its discovery would be fraught with such extensive and lasting benefits to all that section of our State, that the mere possibility of finding it, is enough to sanction a careful inspection of the strata, along this belt of country. It is my intention to devote some further examination to this matter, during the progress of the survey.

We possess a belt of hydraulic cement, near the base of Formation No. VIII, and in a position nearly corresponding to that of the cement beds of New York, though the material seems to wear a somewhat different aspect and composition. It usually lies immediately on the north-western side of the sandstone ridge, next north of the Blue mountain, and dips generally to the north-west. It occurs at several places in the position mentioned, near the Lehigh Water Gap, and also at various points along the same range, towards the Walpack bend of the Delaware. Its color is generally a dark, dull blue, or rather a blueish grey, and its texture nearly that of a compact, earthy limestone.

The water of the Olive Slate Formation, is apt to be hard, and to contain some saline matters, especially sulphates of iron and alumina, or in some instances, carbonate of lime.

The soil is usually thin, and not productive; but carefully tilled, with a liberal and judicious application of lime, it is often found amply to repay the toil and enterprise of the farmer.

This formation will be recognized by the description given of it above, and by its relative position to the other strata of the Appalachian series. It forms the principal stratum in many of the valleys in the counties south-west of the Juniata. It may be traced along the entire line of the valley, which lies at the southern and south-eastern foot of the Table Land of the Allegheny mountain, from Luzerne county, to the Potomac river; and its range through Virginia is even more extensive than through our own State.

The average thickness of the Olive Slate Formation, east of the Susquehanna, is probably not less than 4,000 feet; and on the Lehigh, below Mauch Chunk, it materially exceeds this amount.

On the Susquehanna, between the Blue mountain and the Second mountain, it is very nearly 3,500 feet; and on the North Branch of the same river, it measures, near Cattawissa, 4,471 feet, showing a progressive diminution in the magnitude of the formation, as we advance towards the west.

FORMATION No. IX.

RED SANDSTONES AND SHALES OF THE SOUTH-EASTERN SLOPE AND BASE OF THE ALLEGHENY MOUNTAIN.

Overlying the olive colored and grey slates and sandstones, described in the preceding section, we observe in many extensive districts of the State, another still thicker series of sandstones, and argillaceous shales, very analogous to the previous group in texture and composition, but differing in the one obvious feature of color, which in the greater part of the formation before us, is a brownish red.

It has been already mentioned, that the bottom layers of this group alternate with the upper ones, of the underlying olive colored series. Indeed, many of the intermediate beds show a dusky brown tint, a mingling manifestly of the colors, distinctive of the two respective formations. In the lower half of the mass, red shales, and very argillaceous red sandstones predominate, while the higher parts contain a large proportion of beds of siliceous sandstone, generally reddish or brown, but sometimes grey, greenish grey, and buff colored. In this half of the formation, the rock which occurs no where in very massive beds, has generally a tendency to divide into thin flagstone strata, of one, two or three inches in thickness. This is, in part, owing to the greater or less quantity of mica in it. The mode in which these sandstones were originally deposited in layers, slightly oblique to the stratification, gives it a cleavage, which is not exactly parallel with the true plane of the dip, which is therefore rendered sometimes, a little difficult to be traced with scrupulous precision.

As a formation, this series of reddish slates is even more generally deficient in useful minerals, than the olive colored group immediately below it. It seems to contain some compact red iron ore, especially at certain points in the range which extends along the Allegheny mountain; but no sufficiently rich deposit has yet been developed, to justify a more particular mention of it in the present report. A few very promising places have been partially examined, and a clue procured, which will assist in tracing the ore hereafter, should its quantity sanction a minute exploration. It occurs on Pine creek, Larry's creek, and Lycoming creek. Some of the red shales, as at the Blue hill near Northumberland, are occasionally coated with a very thin pellicle of greenish matter, supposed to be carbonate of copper, but no ores of either that metal or of lead have yet been found; nor do they probably exist in more than very insignificant quantities in this formation, within our State.

Some of the materials of this formation, especially of the higher strata, are well adapted for architectural uses, being durable and easily shaped, though not ornamental, as respects their color. An inexhaustible supply of very superior flagstones for the pavements of towns, might be sent from many quarries of this widely distributed formation.

In regard to the fossils in this rock, a very manifest deficiency is observable, when compared with those in the stratum beneath it.

The change from the more tranquil sediments of the olive colored rocks below, seems to have been accompanied by the extermination of the greater portion of the inhabitants of the ancient deep, in those quarters at least, where these red materials were deposited.

Nor do we find any animal organic remains, except in very rare instances, in either of the overlying rocks, until we reach the uppermost formation of the entire group of strata, or that including the coal, and then only in the beds composing the bituminous coal measures.

Throughout our American formations generally, the red slates and sandstones are remarkable for a deficiency of fossil shells, and other marine animal remains.

Near the junction of this formation, with the coarse, whitish, and light grey sandstone stratum next above it, the reddish colored beds are often replaced by yellowish and buff colored strata, increasing in number as we ascend; and in the south-eastern belts of the formation, the transition from the one rock to the other, is marked by beds of coarse red sandstone, containing numerous large white pebbles of quartz, forming, sometimes, a massive conglomerate. This variety is a durable rock, and fit for many purposes of architecture and construction.

It would not be compatible with my present limits, to more than hint at the general range of this widely extended formation. Composing, as it does, in the north-eastern extremity of the State, some high mountain tracts, having the same geographical range with some of the anthracite coal regions, it was formerly, and is even yet, by many, supposed to be connected with a coal formation.

As no coal can possibly belong to this stratum, from its position in the series, it is the more important to specify in general terms, the mountain belts and districts of country which consist of it.

By far the widest track of this formation is in the counties north-west of our anthracite coal basins. Thus it composes more than two-thirds of Pike and Munroe, occupying the whole of the broad table land of the Pokono mountain, spreading from its south-eastern base, north-westward, as far as the Wyoming and Moosick mountains, and northward, so as to embrace the whole of Wayne, with the exception of the northern end of the Lackawanna coal basin, and a narrow belt of the Olive Slate formation, in the northern side of the county. If forms also, nearly the entire surface of the county of Susquehanna, excepting a similar zone on the side next the New York line, and excepting also some high insulated mountain tracts in the prolongation of the Allegheny, as the knobs of the Mahoopeny and Tunkhannock mountains, which are capped by the next overlying formation. It ranges in almost horizontal strata, along the whole length of the Allegheny mountain, from the North Branch of the Susquehanna to the Potomac, in a belt from one to three miles broad following its southern and south-eastern base, and constituting the entire flank of that mountain nearly to its summit.

Another belt leaves the broad area of the formation in Pike and Monroe, and passing south-westward along the base of the Pokono mountain, crosses the Lehigh; and thence, in a narrow line, follows the valley, at the southern base of the Mahoning, or Second mountain, to the western side of the Susquehanna. In Perry county, this belt expands somewhat in breadth, doubles round the termination of the Cove mountain, and re-crosses the Susquehanna at Duncan's Island. It then ascends the valley of Powell's creek, ranging along the northern foot of Peters's mountain; sweeps northward to the southern base of Berry's mountain, along which it ranges, in a zone about two miles wide, from near the head of Armstrong's creek, westward, across the Susquehanna. It then crosses the Juniata, and pursues the same course, ascending the valley of Buffalo creek for several miles. At the Juniata it curves rapidly back, around the termination of the Buffalo mountain, and runs north-eastwardly, crossing the Susquehanna at Liverpool, and following the northern base of the Mahantango mountain, by the valley of the creek of the same name, to the junction of that ridge with the Line mountain, a few miles east of Zimmermanstown. Its next course is due westward, down the valley of Schwaben creek, along the southern side of the Line mountain. Passing along the Susquehanna, it penetrates some miles into Union county, where it sweeps back again, to assume once more a north-eastern course, encircling the end of the Mahonoy mountain at the river, and ranging along its southern flank and base to the head of Roaring Creek valley. From thence its direction is westward, to Northumberland; the Blue Hill, and a tract for some miles westward, being the end of this particular portion of the formation. But doubling round the end of the Cattawissa mountain, the belt resumes its north-eastern course along the northern slope and base of the Nescopeck mountain, which it follows nearly to the head waters of the Big Wapwallopen creek, where, folding back once more, to take a westward range, it pursues the southern side of the Wyoming mountain, passing some miles beyond its western termination, to the neighborhood of Jersey Town, in Columbia county. Before reaching so far to the west as this, the belt makes an elbow once more, and folds round the end of the Knob mountain, the prolongation of the united ridges of the Wyoming and the Shickshinny mountains. Thence it ranges into a moderately wide zone, along the north-western side of the Shickshinny mountain, and the ridge continuous with it, and meets near the North Branch of the Susquehanna, the termination of the long belt which ranges along the south-eastern base and flank of the Allegheny mountain, from the southern side of the State to this point. From this place of junction, near the North Branch of the Susquehanna, of these two last-mentioned and extensive belts of the formation, it spreads, in almost horizontal strata, over a wide extent of region, through Wayne, Susquehanna, and the north-eastern portion of Bradford counties.

Passing north-westward out of our own State, this Ninth Formation of our series follows the prolongation of the Pokono, through Pike county, in a broad and high chain, augmenting in elevation until it reaches its termination in the grand peaks of the Catskill mountain, near the Hudson. The strata, from the base of the Catskill mountain to within a few hundred feet of its loftiest summits, through a thickness, probably, of three thousand feet, belong exclusively to this formation; while those which crown the highest parts of the mountain are conglomerates, referable to the *tenth* member of the series of our Pennsylvanian rocks. This *ninth* stratum is a conspicuous rock, throughout the whole northern frontier of our State, for sweeping round the base of the mountains, near Towanda, at the eastern extremity of the great bituminous coal region, it ranges westward in a broad belt, parallel to the coal measures, on their northern margin, through the northern portion of Bradford, Tioga, Potter, M'Kean, Warren and Crawford counties, and passes thence into Ohio.

Measured at different places near the several anthracite coal basins, the dimensions of this stratum has been ascertained with considerable exactness, and many facts, regarding its variations in this respect, determined.

The average thickness of the formation must exceed 5,000 feet, the greatest magnitude appearing in the belt along the southern base of the Second mountain, in Northampton, Schuylkill and Dauphin counties, while a gradual abatement is discernible as we pass towards the north-west, and approach the Allegheny mountain.

FORMATION No. X.

SANDSTONES AND CONGLOMERATES OF THE SECOND MOUNTAIN, AND OF THE SOUTH-EASTERN SUMMIT OF THE ALLEGHENY.

We ascend from Formation No. IX, through a series of alternating strata, usually several hundred feet in thickness, comprising red shales and red argillaceous sandstone allied to that formation, and interposed grey sandstones and red and grey conglomerates, connected with the heavy overlying deposits of Formation No. X, which formation I now proceed to describe.

The lower portion of the mass includes white and grey siliceous sandstones, with interstratified beds of dark bluish and greenish slates, sometimes resembling the shales contiguous to coal, by having occasionally sufficient carbonacious matter in their composition to ignite, when highly heated.

The middle and upper strata are alternations of coarse siliceous conglomerates, and grey, bluish grey, yellowish and white sandstones, including, in some districts, thin layers of olive colored and black slates.

The principal useful applications of this rock are to the purposes of architecture. Great caution, however, is requisite in the selection of the particular layers. A too indiscriminate introduction of its various sandstone beds, but especially of its lower strata, which alternate with the upper ones of Formation No. IX, has already resulted in the construction of some of our public works, in the destruction of an immense amount of capital to Pennsylvania. From the fact that a portion of its strata resemble, in some degree, a part of our coal measures, and at the same time, overlie a red shale and sandstone deposit, having a considerable analogy to that beneath the anthracite coal basins, a mistaken belief prevails in the minds of many of our citizens, that this rock belongs to the genuine coal formation of the State. Explorations in search of coal, sometimes expensive ones too, are almost daily undertaken, incited by visionary hopes, which have no better foundation than vague mineralogical analogies, and unscientific attempts to identify our strata.

Upon the summits of the Allegheny mountain where the upper surface of this rock immediately adjoins the base of the conglomerate stratum upon which all our coal measures repose, (there being no red shale interposed,) the difficulty of recognizing the true character of this formation is considerably increased, and erroneous anticipations respecting the occurrence of coal in that part of its range are consequently frequent; but, unless indeed it be in Virginia, where from the investigations of my brother, Professor W. B. Rogers, it would appear that some small and as yet unproductive beds of coal do really occur in this rock or its equivalent, I entertain no expectation that research will ever develope a profitable seam of either variety of that mineral in this formation.

For the present, a sufficiently correct idea of its range is presented in the following brief enumeration of the mountains and ridges of our State which consist of it.

Commencing our tracing on the south-east, it caps the Big Creek mountain, east of the Lehigh, at Mauch Chunk, and the Broad mountain a continuation of this, as far westward at least as the Little Schuylkill.

It forms the main summit and northern side of the second mountain from the Lehigh to Perry county, where it composes the Cove mountain. It forms Peters's mountain, Berry's mountain reaching to the Juniata, the Buffalo mountain and its extension, the Mahantango mountain; also, the Line mountain and the Mahonoy, with its prolongation, the Little mountain: thence it extends along the Cattawissa mountain and its continuation, the Nescopeck mountain, to where this flattens out and joins the Wyoming or Moosick mountain; the whole of which, from Wayne county to its junction with the Shickshinny mountain, in Columbia county, consists of this formation. It composes, likewise, the Schickshinny and its continuation, the Lackawanna mountain, encircling, through this and the Wyoming mountain, the whole of the Wyoming coal basin. It sweeps north from the eastern part of the Broad mountain, keeping east of the Lehigh, until, in the neighborhood of Bear creek, it crosses this river, and forms the flattened table land at the eastern end of the Nescopeck. The southeastern side of the summit of the Allegheny mountain, consists also of this rock, throughout its entire course, from Maryland to the North Branch of the Susquehanna, beyond which, I believe the formation is prolonged in the highest summits of the Tunkhannock mountain.

This rock occurs, fully developed, also, in Bedford and Huntingdon counties, holding a corresponding position outside of the coal basin of the Broad Top mountain, which it completely encircles, ranging through Sideling hill, Terrace mountain, part of Allegrippus mountain and Harbour mountain, following these ridges in their continuation southward.

The thickness of this formation has not yet been determined, except at a few places in the State. From the measurements that have been made, it would appear to vary from about 2,200 feet, which is nearly its greatest depth in the belts adjacent to the anthracite coal basins, to a thickness of only a few hundred feet in other parts of the State.

FORMATION No. XI.

RED SHALE OF THE ANTHRACITE COAL REGIONS.

The next formation in the ascending order, is remarkable for retaining its characteristic features and composition, with more uniformity than perhaps any other in our entire series.

It consists, almost invariably, of argillaceous red shales, and soft argillaceous red sandstones. Toward the base of the stratum when the materials partake somewhat of the silicious character of the underlying sandstones last described, it embraces some beds of hard, compact, red sandstone, with occasional alternating layers, of a similar composition, but of a grey color. Toward the middle of the mass, the sandstones are more argillaceous, and softer, but still include beds of the harder grey variety, while the red shale is somewhat less abundant. This mixed character prevails throughout the upper third of the deposit, until we approach the base of the conglomerate stratum above, near which we generally behold a moderately thick alternation of the remarkably dissimilar rocks of the two adjoining formations, the red shales and soft red sandstones being interstratified with coarse grey sandstones, and excessively coarse and massive conglomerates.

If much circumspection be used, the middle and lower portions of the formation may be made to yield very excellent flagstones and building materials, being procurable in masses of very convenient shape, and possessing every requisite in respect to compactness and durability.

Many of the beds of this red shale and sandstone series are more or less calcareous, and a few of them are almost enough so, to be considered bands of true limestone. The layers of this character, closely resemble each other in composition, consisting of a kind of conglomerate formed of small ovate pebbles or kernels of limestone, of a light blueish grey, and sometimes a faint greenish or reddish tint, imbedded, though rarely in contact with each other, in a paste of soft argillaceous red shale. Occasionally the rock contains such an abundance of these little limestone pebbles, which, in shape and size, are not unlike the smaller sort of beans, and the cement uniting them is so calcareous, that it possesses almost the purity of an ordinary limestone. When of this description, it differs but little from common light blue, and greenish grey limstones, except in the mottled appearance arising from its pebbles. This least impure variety, has in a few instances been calcined, and has been found to afford a lime, which, though not very pure or white, is yet tolerably well suited for making mortar, though better adapted to the purposes of a manure for the soil.

The external aspect of this calcareous rock is so peculiar, that any attentive observer will readily recognize it, even from the foregoing brief description. Its weathered surface possesses a singularly decayed and worm-eaten appearance, in consequence of the greater solubility of the calcareous pebbles over the red argillaceous earth surrounding them, causing the outside to be studded with irregular pits from the partial removal of the small lumps of limestone. The inspection, therefore, of the weather-worn exterior, will exhibit better than a newly fractured surface, the relative amount of the carbonate of lime, compared with the impurities in the rock.

The upper part of the formation would generally appear to contain the purest bands of this calcareous rock, but in some places they abound more in the middle and lower portions. For every such conglomerate bed, pure enough to calcine into lime, many will occur much too impure to warrant the experiment.

The thickness of these bands, ranges from six feet to a few inches. A layer, pure enough perhaps to afford an indifferent lime, exists on the south side of the Second mountain, in the valley of Tumbling run, three miles east of Mount Carbon. Another lies in the valley of Locust creek, about two miles northwest of Tamaqua, and presents rather better indications. Other beds, probably however, much too impure for practical application, occur in the southern part of the Gap of the Sharp mountain, south of Tamaqua. The same rock is found near Mauch Chunk, and near Beach Grove at the western extremity of the Wilkesbarre coal basin. I have met with it tolerably pure in the red shale tract, embraced between the Broad mountain and the Mahonoy mountain, not far from the road leading from Pottsville to Sunbury; but one of the purest belts yet examined, occurs immediately at the western end of the Mahonoy coal basin, in the red shale rocks near the outer base of the Big mountain, immediately at its termination on the Little Mahonoy creek.

I deem the calcareous rock of this last mentioned spot, which may easily be found, to deserve a careful trial by the farmers in its vicinity.

These are a few of the places in which this stratum has been met with. Enough is known to indicate, certainly, that each of the anthracite coal basins is encircled by one or more bands of this rock. Whether it exists of sufficient extent and purity, to furnish a supply of lime for the agriculture of the red shale valleys, contiguous to the coal fields, is a question which further researches in these regions alone can settle. But no pains should be spared, to ascertain its real value, since the valleys where it exists, are far remote from the limestone districts of the State.

A very brief description will, for the present, suffice to designate the range of the red shale formation. Encircling in a continuous zone, all the anthracite coal basins of the State, it usually constitutes a chain of deep and narrow valleys, enclosed between the ridges of Formation No. X. on the one side, and on the other, those containing Formation No. XII. composing the margin of the coal measures.

The maximum thickness of this formation occurs, apparently, in its south-eastern belt, or that which ranges along the south side of the southern anthracite coal basin. From accurately conducted measurements made at Pottsville, the depth of the stratum, at that place, is about 2,949 feet.

FORMATION No. XII.

CONGLOMERATES AND SANDSTONES, IMMEDIATELY BELOW THE COAL MEASURES OF THE ANTHRACITE, THE BROAD TOP, AND THE ALLEGHENY COAL REGIONS.

The stratum which occupies the next place in the series, is a group of siliceous conglomerates, and coarse siliceous sandstones, immediately subjacent to all the coal measures of the State, both in the anthracite and bituminous coal regions. It reposes upon the red shale formation, just described, not only around all the anthracite basins, but also around the bituminous coal measures of the Broad Top mountain; while it rests directly on the upper surface of the sandstones of the next lower formation (No. X.) along the entire length of the Allegheny mountain, the south-eastern margin of the great western coal field; the red shale deposit not extending that far towards the north-west.

Confining the present description to the formation as it underlies the several anthracite deposits of the State, its mineral character which is well marked, and liable to but little variation, may be given in very few words. The whole rock, which is usually several hundred feet thick, consists of massive strata, of coarse quartzose conglomerates, alternating with white, grey and brown sandstones, of rather diversified texture and composition, including occasionally, a few thin beds of dark carbonaceous shale.

The most abundant and characteristic rock, is the conglomerate. This occurs in very heavy beds, especially towards the bottom and the top of the formation. Its materials are chiefly pebbles of white quartz, with a few interspersed ones, derived from the three rocks at the bottom of our series—the sandstone, the limestone and the slate, of the Kittatinny valley. The limestone itself, would seem not to have been sufficiently hard to resist the attrition which accompanied the strewing of this enormous bed of shingle over the bottom of the ancient ocean, but the chert or flint belonging to the formation, was better able to withstand the abrading action, and its pebbles, therefore, not unfrequently enter into the composition of the rock.

In the conglomerate, there is rarely much sand or other finely divided matter, separating the pebbles from each other, which are most commonly in close contact; the rock being nothing else than an aggregate of rounded fragments of white quartz, varying from the size of a pea, to an inch in diameter.

We observe a regular, and manifest diminution in the size of the component pebbles, and in the thickness of the stratum, as we pass successively from the Sharp mountain, on the southern side of the southern anthracite region, to the belts which surround the middle and northern basins. At the same time, the materials assume a more uniform size, and the entire mass grows more homogeneous; becoming a nearly pure quartzose conglomerate. In some of the southern belts, the pebbles vary in dimensions, from the diameter of small shot to that of an orange, which indeed, they occasionally surpass.

It is a fact, of no small interest, as pointing out the violent action which immediately preceded the deposition of the first beds of coal, that the lowest seam in some places, is in almost direct contact with one of the very coarsest and most heterogeneous of the conglomerate beds of this formation.

It would appear, indeed, that the violent movements of the earth's surface which were the prelude to that new and remarkable order of things, which gave origin to the coal, and its accompanying strata throughout the whole wide region embraced by our enormous coal fields, were not wholly terminated when the production of this material commenced. For, at various places on the margin of the southern or Pottsville basin, a seam of coal occurs beneath a thick and very massive stratum, of the coarsest sort of the conglomerate.

The uses to which this twelfth formation of the series is applicable are few. For massive structures, such as the embankments, and walls of railroads, the rock of the conglomerate beds is exceedingly well adapted; and many of the finer grained sandstones are very fit for building stones. The compact, and purely quartzose conglomerates, when, not too coarse, may be converted in *millstones*, some having been occasionally made, it is said, of this rock, on the margin of the northern or Wilkesbarre basin. The material would appear to be not inferior for this purpose, to that found at Esopus, on the Delaware and Hudson canal, which belongs to the conglomerates of Formation No. IV. So nearly alike in their constituents and aspect, are the two rocks, that it is sometimes a matter of difficulty to distinguish between them.

The maximum thickness of this conglomerate formation, seems to occur towards the eastern part of its most southern belt, or that which forms the Sharp mountain. Thus, at Tamaqua, it is probably not less than 1,400 feet, whereas, at Pottsville, it is but 1,031 feet, and at Pine Grove, considerably less.

Its thickness, in the eastern portion of the Middle Anthracite Region, has not yet been positively ascertained; but at Girardville it does not probably exceed 800 feet; while towards the western end, at the gap through the Big mountain, traversed by the Shamokin creek, it is about 700 feet. At Nanticoke, on the north side of the Wilkesbarre basin, it measures about 300 feet; and near Beach Grove, at the western end of the same valley, about 200 feet would seem to be the total thickness.

This diminution in the thickness of the formation, as we proceed northward and westward, appears to be continued to the coal regions bounded by the Allegheny mountain; for at Towanda, where it caps most of the higher mountains and supports a shallow mass of productive bituminous coal measures, the dimensions of this conglomerate do not, probably, exceed fifty feet.

It is not a little curious that this white siliceous conglomerate underlies, not only all our vast bituminous coal region, of which it forms the south-eastern boundary along the Allegheny mountain, and the northern border along the high table land of our northern counties, but it occurs, in a similar relative position, along the edge of the same great coal basin, in its continuation southward through Maryland and Virginia.

FORMATION No. XIII.

THE ANTHRACITE COAL MEASURES.

I come next to describe, in an equally brief manner, the Anthracite Coal Measures. These, with the contemporaneous bituminous coal deposits of Broad Top mountain, compose the last produced or uppermost formation of the extensive system of strata occupying the Appalachian region of Pennsylvania. None of the other formations consist of so miscellaneous a group of materials; for these coal measures comprise, besides the beds of anthracite, an entensive series of shales, sandstones and conglomerates, in frequently repeated alternations.

Among the coal seams, at the base of the series, we often find a conglomerate of the very coarsest sort, identical, in all particulars, with the rock which characterizes the upper portion of the next underlying formation. This rock marks the gradation from the one set of deposits to the other, and points to the curious fact, that the processes which brought together the materials of the coal, commenced before the previous movements that caused the conglomerate, had wholly ceased. This very coarse aggregate, has rarely more than one or two coal beds below it; and ascending a little in the series, we find that its place is supplied by thick beds of shale, and masses of soft argillaceous sandstone, with occasional strata of coarse siliceous sandstones, some of whose layers have a sprinkling of pebbles, which give them the aspect of conglomerates. These pebbles are smaller and more irregular than those composing the rock at the very base of the series. The coal, and the slates immediately in contact with the coal, lie interstatified with these numerous coarse beds in an alternating group of great thickness.

Between the conglomerates, or even the coarse sandstones, and the beds of coal, argillaceous sandstones and blue shales are almost invariably interposed. The predominant rock, of the upper part of the series, is a compact blue sandstone, containing much argillaceous matter and oxide of iron, which cause the atmospheric agents to decompose it superficially, and to impart a dingy brown color, and a tendency to a conchoidal fracture, and to a scaling off at the corners.

The shales, which are next in importance to the argillaceeus sandstones, are commonly of a dark blue or blueish grey color, when freshly broken; but many of them, by exposure to the atmosphere and to the vissitudes of the seasons, assume a brownish ochreous hue, and crumble rapidly to pieces. Occasionally these shales contain highly ferruginous bands, in some of which occur layers of tolerably rich argillaceous iron ore. In the Anthracite Coal Measures, as a general rule, this ore does not appear to exist, in that abundance which it exhibits in many portions of the bituminous coal series, north-west of the Allegheny mountain. Its quantity is, however, very considerable, and hopes are entertained, that, in the course of of the enterprising mining operations, and the geological explorations now on foot, valuable bands of the ore may be developed.

These blueish shales also contain, though not abundantly, very beautiful impressions of Ferns and stems of Calamites, and in the lower portions of the deposit, the stems and leaves of other curious vegetable fossils, as Lepidodendron, Sigillaria and Cactus.

In the immediate vicinity of the seams of coal, these shales become more or less carbonaceous, and acquire a darker color, and a more purely argillaceous texture. On such, the miners bestow the name of *coal slates.* These slates, it is generally thought, differ materially in appearance and composition, accordingly as they lie above or beneath the coal seams. The overlying slate often contains innumerable extremely thin sheets of pure anthracite, minutely interlaminated with equally delicate layers of slate. This is technically termed *bone coal,* and is frequently mistaken, by the inexperienced, for pure anthracite, though it is easily recognized by its tendency to split into thin parallel layers, and by the number of the ferns and other delicate vegetable impressions usually found in it.

The underlying slate, on the contrary, is of a much tougher consistency, and of a more regular or well defined fracture, breaking into firm splintery masses, instead of loosely aggregated scales.

These slates, in contact with the coal beds, vary from one to twenty, or even thirty feet in thickness, and not unfrequently occupy the entire space between the two contiguous coal seams.

It would lead me far beyond the limits which I have assigned to the present brief sketch, to attempt even a general description of the several vast anthracite coal basins of the State. As was intimated, in the early part of this report, many portions of these coal basins have yet to be explored in detail; want of time and of adequate assistance, having made it impossible to extend the minute investigations of the survey beyond certain limited districts.

Yet the mass of observations already collected, would, if it were expedient to introduce them here, swell this report to more than four times its present magnitude. To be intelligible and really useful, they would require exemplification by geological maps, sections, and numerous other drawings, the publication of which, at the present time, would be premature. I shall, therefore, postpone giving any systematic description, either general or particular, of these coal regions, and confine myself entirely to two or three insulated topics, connected with peculiar features in their structure, which are of a nature to influence the success or failure of mining operations in certain tracts and districts.

When we advert to the usual shape and structure of the several great anthracite tracts of the State, we perceive that they are long and irregular basins, which have assumed their form from the elevation, on all sides of them, of the underlying rocks of the country, in a series of nearly parallel belts, from which the strata dip in opposite directions, or, technically, in a series of anticlinal axes. Thus the northern margin of the Pottsville basin, and the southern one of the Beaver Meadow and Mahonoy, or Shamokin basins, are the joint results of the elevation of the rocks below the coal, in the intervening tract of the Broad mountain and its spurs; and, in like manner, the particular sub-divisions of each basin, have been made to assume a similar basin or trough-like form, (or that in which the stata dip from the margin inwards,) in virtue of the same force of upward protrusion of the underlying formations, operating to tilt aside the uppermost or coal bearing deposits. This is well exemplified by the manner in which the Wiconisco basin has been severed from the Dauphin county extremity of the great basin at Pottsville, by the elevation of the subjacent rocks along the anticlinal axis, which passes through the country lying between Berry's and Peters's mountains. This axis, gradually dying out to the eastward, permits these two mountains to coalesce, bringing together the two red shale valleys on their north and south, and finally, the two coal valleys themselves, near the head waters of the Swatara creek.

Connected with this violent upheaving action of the strata outside of the coal basins, enormous parrallel *wrinklings* of the coal measures themselves, have taken place, causing great intricacy in the internal structure of many parts of these regions. This is augmented by the existence of great dislocations, the results of the same subterranean movements.

Directing our attention to the southern or Pottsville basin, for the illustration and application of these facts, let us examine some of the peculiar features, which have there arisen from the agencies alluded to. The most conspicuous point, in the structure of this coal valley, and one intimately connected with nearly every other feature which belongs to it, is a remarkable dislocation, which I have proved to extend nearly from end to end of it, ranging a short distance north of the northern foot of the Sharp mountain.

The strata giving way along this line through a length of perhaps fifty miles, those on its southern side have experienced an enormous downthrow. At the same time, the rocks of the Sharp mountain, through an extent, probably, of thirty miles, have been heaved towards the north, and tossed beyond the vertical position, so that these ponderous conglomerates lean, in an inverted attitude, on the entire thickness of the coal measures, which must lie buried, in a more or less crushed condition, for several thousand feet beneath its northern base.

At Pottsville, at Tamaqua, and at Pine Grove, the exact position of this great fracture of the strata has been detected; while ample and satisfactory evidence has, at the same time, been collected, which goes to show, that it ranges continuously through the intermediate tracts.

In consequence of the disruption of the coal measures, near the northern base of the Sharp mountain, and the *overtilting* of its strata, the coal seams, which occupy its northern flank, and which are several in number, have sustained a greater or less degree of crushing action, the result of a sliding of the beds in the plane of their stratification. Indeed, it is not to be supposed, that a group of massive strata, many thousand feet in thickness, and composed of materials of almost every degree of tenacity known in rocks, could be upheaved from their originally horizontal position, and tossed into a vertical posture, and even beyond it, without undergoing much displacement in a direction parallel with the surfaces of the beds. This action resembles the sliding upon each other of the leaves in a ream of paper, when we suddenly elevate one side, and permit the parts of the mass to settle into new relative positions.

In a vast pile of stratified rocks, thus disturbed, the greatest amount of movement, and consequently, of crushing force, would take place in the *weakest* layers, which, in the case of coal measures, would be the beds of the coal itself. At the same time, the strata would experience, especially if they were tilted into a nearly vertical attitude, an unequal lateral *bulging*, such as the sheets in the ream of paper will show, when it is loosely placed on one end, and the *lateral* pressure, which preserved them in their places, removed. Precisely these results are witnessed in the coal measures of the northern slope of the Sharp mountain, where the coal seams, in many places, exhibit the effects of a rubbing pressure to an extraordinary degree.

For a great space in one of these, it is difficult to find a mass of coal exceeding a nut in size, which does not give proof, by its numerous fissures and highly polished surface, that its parts have been violently crushed. The whole mass has a tendency to crumble into small lenticular flakes, which, in consequence of the friction which they have undergone, possess a lustre and a color somewhat resembling black lead, from which circumstance the bed has acquired the name of the Plumbago Seam. The lateral bulging of the strata is shown by the variability in the thickness of the coal seams, the roof and floor of the bed approaching sometimes almost to touching, and at others, receding to beyond the full space which should divide them. This alternate contraction and dilatation of the layer, occurs not only in the direction of its range, as may be seen in the horizontal galleries or drifts, but it exists in the opposite direction or that of the dip, and will render it as difficult to mine such seams, with success, by the method of *slopes* as by that of *levels*. To show that these yieldings in the strata pervade the Sharp mountain, throughout the greater part of its length, it is only necessary to mention, that, in every few hundred feet, a change in the direction or bearing of the rocks is observable ; the levels, in the several mines which have been worked in the side of this mountain, between Pottsville and Port Carbon, exhibiting very frequently quite a serpentine course, the flexures, however, being very gentle.

The variations, in the course of the strata, are usually embraced between a direction, north sixty degrees east, and one north eighty degrees east, so that any abrupt twist in the range of the rocks cannot occur, except, as in the case opposite Middleport, where the whole mountain, as one mass, has been violently dislocated in a direction transverse to the strata.

I would not convey the idea, from what has been said, that all the coal in the Sharp mountain is crushed, and all its seams irregular.—Even were this the case, it would not follow necessarily, that some portions of them might not well repay the cost of mining, especially on the plan of drifts, entering at the ends of the strata in the gaps which divide the mountain.

It will sometimes happen, that a slightly crushed or fragmentary condition in a coal seam will require less excavation, and permit the operations of the miner, if on a moderate scale, to be conducted with more economy. At the same time, I would wish distinctly to make known my belief, that, throughout this tract of the coal region, the causes, alluded to above, must render the business of mining these nearly vertical and overtilted seams, precarious in a high degree.

Tunnels of several hundred feet in length, are occasionally carried through the hard coal measures of this lower portion of the series, to gain access to the several thick beds of coal which lie in the side of the Sharp mountain; but they appear invariably to have been undertaken, under a persuasion which has not yet, in a single case, been realized, that a portion of the formation could be reached, unembarrassed by the features upon which I have just commented. My own conviction is, that those peculiarities in the structure of the Sharp mountain, constitute, from their frequency, a general rule, having perhaps, a few rare exceptions, which will hardly, I conceive, unless indeed, they are distinctly known to be exceptions, justify the expense of mining the coal, in case it must be done by tunneling.

An interesting fact, concerning the changes in the dip of the coal measures, included between the Sharp mountain, at Pottsville, and the Broad mountain, goes far to confirm the views here adopted, respecting a tossing over towards the north, of the strata on the south side of the dislocation. It refers to the particular form which generally prevails in the anticlinal elevations of the strata in this part of the basin: namely, the greater steepness of the dips on the northern, compared with those on the southern side of these axes. It is a common remark among the miners, that the north dipping seams are steeper than the south dipping ones, and of less continuance. The reason for this is very intelligible, if we will advert to the manner in which the forces operated on the strata at the time when they were elevated.

The rising of the underlying formation, in the lofty axis of the Broad mountain, tilted the coal measures southward, at a considerable angle, over the entire width of the valley, as far as the great dislocation; but the action in that direction, must have been met by the far more resistless force exerted by the Sharp mountain, pressed forward and leaning towards the north by its whole momentum and weight, so as to abut against the edges of the fracture. The tendency of this compression from the south, would be to wrinkle the strata, not in symmetrical anticlinal undulations, as we see them in the other basins, but to thrust the upper part of each fold or wrinkle, towards the north, and thus to steepen the northern inclinations more than the southern.

The waves on a surface of water, will explain this. When the wind entirely lulls, the slope is equal on both sides of every wave, but when the wind presses strongly from any quarter, the top of each wave is urged forward from the wind, and the inclination on the far or leeward side, is considerably the most abrupt. The geological section which has been measured across the basin at Pottsville, shows the existence of at least five important anticlinal elevations, or changes of the dip, and it holds true of most of them, that the dips towards the north, much exceed those towards the south. This applies even to the axis in Mine Hill, which is an anticlinal elevation exposing the uppermost strata of the conglomerates, below the coal, occurring at a distance of more than three miles from the dislocation, where the horizontal thrust towards the north, must have been exerted.

Undulations in the dip of the coal measures, caused by numerous parallel anticlinal axes, are of frequent occurrence throughout all the anthracite basins. An exact knowledge, therefore, of their range and magnitude, and of the peculiarities which sometimes attend them, relating, for example, to the particular direction and character of the fractures and displacements, must prove of great importance to those who embark their capital in mining operations. These displacements, though the apparent cause of the intricacy and confusion so common in the stratification of these coal regions, often maintain among themselves, certain features in common, which, when understood by the miner, may frequently lead, in the prosecution of his work, to practical views of incalculable advantage. Thus, in the vicinity of Pottsville, the intelligent colliers have long been aware of the relative unproductiveness of the north dipping portions of the strata, though from not recognizing the cause, the fact has not been admitted as a general rule, to the extent which it deserves, and injudicious enterprizes are, therefore, often undertaken in total disregard of it. At a later stage of the survey, it is believed, some useful generalizations upon this important subject will have been arrived at; for the present I will allude very briefly to one or two, not however, of a very local application.

A striking one is, that these anticlinal elevations of the strata rarely observe a direction quite parallel with that of the coal beds themselves. It would appear, that from the neighborhood of Pottsville, eastward, towards Mauch Chunk, the undulations in the dip most usually draw nearer to the Sharp mountain side of the basin, as they extend eastward, thus crossing the true course of the coal measures, a little obliquely. In the Shamokin basin, or the western half of the great central anthracite region, the reverse would seem to be the case: each conspicuous anticlinal axis, showing a tendency, in running eastward, to approach the northern barrier of that basin.

It is very important, from the great length of the levels and longitudinal galleries, in many of the mines, some of them being nearly a mile in extent, to ascertain for each neighborhood, the quarter, whether east or west, towards which these undulations most commonly flatten out and disappear.

The vicinity of Pottsville was alluded to, to show a peculiar feature of irregularity in the anticlinal axes, consisting in the greater steepness of the north dips compared with the south.

The coal fields at the eastern end of the great middle region, will illustrate a very different structure, arising on the other hand from undulations of remarkable symmetry. The whole of this tract consists of a rather high, rolling, table land, between the summits of the Buck and Spring mountains—the outer barriers of the coal measures. It is traversed longitudinally, or in a nearly east and west direction, by three, and probably in some quarters, four, nearly parallel, gently swelling ridges, dividing the region into about four very moderately depressed valleys. These valleys are so many almost regularly formed little coal basins, in which the coal measures, as a general rule, have a very gentle dip towards the interior of each basin, or away from the bounding ridges. The ridges contain broad, rounded, obtuse, anticlinal axes, having the dips on both sides symmetrical, and expose across their summits, and on the upper portions of their acclivities, the conglomerate stratum which constitutes the formation beneath the coal. Much capital may, therefore, be thrown away in explorations for coal upon these ridges, or in the tracts through which their anticlinal axes are prolonged, towards the east and west, if due attention be not paid to the structure of the coal field containing these lines of elevation. Some of the valleys on the other hand are richly supplied with coal, two or three of the seams which are those at the base of the formation, being of great thickness, though the total depth of the coal measures, when compared with that in several of the other regions, is materially less.

Besides these undulations of the dip, and other disturbances which interrupt the regular basin-formed arrangement of the coal measures, in lines nearly longitudinal with the course of the strata, there are systems of *transverse dislocations* in many of the basins, less obvious to the explorer and miner, but exercising, if any thing, a still more serious interference with mining operations. To take the southern or Pottsville region for our illustrations, the numerous gaps and notches in the Sharp mountain, which is its barrier on the south, are nearly all of them connected with great fractures, extending *across* the range of the strata. These fractures, indeed, appear to have caused those gaps or breaches in the mountain, by presenting a barrier, broken at various points, to the scooping floods, which have swept alike across our valleys and our loftiest ridges.

A frequent, though not an invariable consequence of these transverse breaks, is the derangement of the regular continuity of the strata on the opposite sides of the vertical plane in which the crush has taken place. The coal measures are thus abruptly broken off or greatly twisted and thrust out of their usual range, or to use a mining phrase *horrizontally heaved*, to the north or south of their proper position. This is most apt to occur at the streams, many of which flow through transverse valleys caused by the dislocations here spoken of. Seams of coal extensively mined and familiarly known on one side of a rivulet, often thus elude discovery, when sought for on the opposite bank.

The successful recovery of these, would, however, be greatly facilitated, by a knowledge of the direction and magnitude of the horizontal heaves in each particular neighborhood. That knowledge can only be accumulated, by the joint observations of the geologist and the miner—the one devoting himself to the study of all the phenomena which can cast light upon the inquiry, the other treasuring the hints which the first can furnish, and directing his attention to amass as great a variety as possible of local facts, collected from the mines in the course of his subterranean labors.

One of the most obvious of these transverse dislocations, crosses the Sharp mountain and the coal measures at Lorberry creek, northwest of Pine Grove. East of the gap by which that stream passes through the Sharp mountain, the strata, in this southern barrier of the coal field, range about south 72 degrees west, and dip in an *overtilted* attitude, at an inclination of rather less than 70 degrees southward, while, on the west side of the gap, the course of the rocks is south, 57 degrees west, their posture being nearly vertical; the whole mountain, and the coal measure north of it, being at the same time moved, or heaved towards the south, as much as thirty yards.

It is probable, that a fracture of the same kind passes through the gap of the West Branch of the Schuylkill, two miles west of Pottsville; for the coal measures which, eastward from this neighborhood, are traceable, with a moderate degree of regularity, for several miles, appear no longer in their ordinary range, when they are sought for on that stream. On the West Branch of the Norwegian creek, the strata indicate, in like manner, a displacement from their usual line of bearing; and the efforts to trace some valuable coal seams west of this water, have hitherto ended in disappointment. Whether, at these supposed cross dislocations of the strata, those on the western side of the line of crush have been heaved southward, as in the instance at Lorberry creek, or northward, is a question, the solution of which would be fraught with important benefits to that portion of the coal region.

By far the most conspicuous north and south disruption of the coal measures and their southern conglomerate barrier, is displayed in an enormous dislocation of the entire chain of the Sharp mountain, about nine miles east of Pottsville, by which the whole mass of the mountain, on the eastern side of the break, has been moved northward, through at least one-fourth of a mile, throwing, of course, all the coal seams far out of their regular position.

A very analagous displacement in the same mountain ridge, and on a scale scarcely less considerable, occurs on the southern side of the basin, at the Summit Mines of the Lehigh company, where the eastern prolongation of the Sharp mountain has been thrust northward of the western, through a distance of many hundred yards. This has formed a broad, elevated plateau, between the two disjoined summits of the mountain, from which all the upper coal measures have been swept away, and the strata denuded precisely to that fortunate depth, necessary to lay the vast deposit near the base of the series, accessible on the surface of the hill. Thus, an immense mass of coal has been spread out over a wide space, in a nearly horizontal position, disturbed, however, by numerous sharp east and west wrinkles, or parallel anticlinal axes. These undulations point distinctly to the transverse disruption of the mountain and the adjoining coal measures, as the origin of this remarkable table land.

In all the three instances here adduced, of great cross fractures affecting the Pottsville basin, the strata to the *eastward* of the dislocation are thrust forward towards the *north;* and such, though probably liable to many exceptions, would seem to be the general rule in this southern coal region. The numerous gaps and breaks in the line of the Blue mountain, or Kittatinny, exhibit, very generally, a corresponding law.

This is shown, by measurements, at the wide gap of the Susquehanna, above Harrisburg, and is manifest, to the eye, in the bold notch called the Water Gap of the Delaware, where the strata that rise into the summit of the mountain, on the New Jersey side of the river, are thrown several hundred feet to the north of those, in a corresponding position in Pennsylvania. I conceive these transverse dislocations to pervade all the great ridges and valleys of our Appalachian region, and to be a primary cause of most, if not all, of those deep notches which are known by the name of Water Gaps, and which cleave so many of our high mountain ridges to their very bases.

An interesting generalization, and one of some practical importance to the explorer for coal, especially in certain districts, is that which indicates that *all* the anthracite coal measures of the several basins, are but the several portions of *one* great formation, which, previous to its elevation from beneath the waters in which its beds were deposited, constituted a single continuous mass of strata. I am led to this inference, not merely from general views of geological causation, in reference to all our formations, but after a careful comparison between the same parts of the series in each separate basin. Thus, the lower coal mèasures of the Pottsville basin, bear a striking resemblance to those in the same position in both the middle and northern coal fields; making proper abatement, of course, for the progressive changes discernible in all the strata when traced over extensive areas. I will not, at present, assume it as established, nor even suppose it susceptible of positive demonstration hereafter, that the great coal seam which lies near the base of the coal measures, commonly from the second to the fourth in position above the conglomerate, is one and the same stratum in all the several regions. Many facts, however, lend a high degree of probability to the conjecture. There being but one seam of such magnitude in each basin, its occurring in the same part of the series, the close resemblance between its neighboring strata, when we compare these, in the several basins, aud the exact identity of the vegetable fossils of the slates, and the want of this identity with those in the higher portion of the mass, all furnish ground for the belief, that this enormous stratum, wherever it occurs, is but a remaining part of one originally more widely diffused deposit belonging to all the basins.

Like nearly all the other strata, of the entire series of the formations, in the quarter of Pennsylvania which embraces the anthracite coal, this seam, considering the thick bed in each basin as the same, decreases in thickness as we follow it toward the north and west. Thus, at the great coal quarries called the Summit Mines of the Lehigh company, which are on a terrace on the side of the Sharp mountain, the depth of the deposit, including its numerous layers of coal and alternating thin bands of slate, is about fifty feet, while that of the corresponding bed on the north side of the same basin, both at Pottsville and the Nesquehoning mines, is about twenty-eight feet. In the Beaver Meadow and Hazelton basins, its average thickness is about twenty-two feet, which is very nearly that of the corresponding bed at Wilkesbarre and Carbondale, in the northern basin. This shows an abatement in its thickness, going northward, and making a similar comparison between its dimensions, as we meet it in passing from the east toward the west, in each basin, we perceive a corresponding diminution in the thickness of the mass to take place in that direction also. Thus the thickness at Beaver Meadow somewhat exceeds that at the gap of the Little Mahonoy near the western extremity of the Shamokin basin, while the depth at Wilkesbarre surpasses that at Nanticoke.

In considering the large coal seam, near the bottom of each series of our anthracite strata, as belonging to a single stratum, I wish to explain, that I regard these several thick deposits as formed most usually, by the junction of two or more smaller beds brought together by the thinning out of the interposed layers of slate and sandstone. Thus, observation renders it highly probable that the enormous bed of coal, at the Summit Mines of the Lehigh company, owes its thickness of more than fifty feet to the coalescing of three or four of the thick and closely adjacent seams to be seen near the bottom of the formation at Tamaqua, about five miles further to the west. With this limitation of my meaning, I conceive it probable that the main coal bed, near the bottom of each set of coal measures, occupies the same or an equivalent position in the strata in all the basins, and that a portion at least of the mass is identical, and was once continuous from one anthracite coal region to the others.

GENERAL OBSERVATIONS.

In taking a general review of the extensive series of our Appalachian formations, now for the first time systematically classified and described, our attention is forcibly arrested by their vast thickness, the immensity of their range, and the inexhaustible stores of mineral treasure which they contain.

From the base of the entire series, where the bottom of the lowest sandstone is in contact with the primary rocks of the South mountain, to the uppermost beds of the Anthracite coal measures, the absolute depth of this enormous group of strata in our counties, east of the Susquehanna, cannot be less than *forty thousand feet* It is worthy of remark, that probably no other district in the entire Appalachian chain, from the Hudson river, to Northern Alabama, presents our American lower secondary rocks on an equally expanded scale, or so admirably developed for Geological investigation.

The gigantic magnitude of the areas, covered by these thirteen formations, may be conceived, when I state that they not only occupy the entire surface of Pennsylvania, with the exception of the corner of the State, southeast of the South mountain, but that, with a few interpolated strata, they comprise three-fifths of the territory of the United States, east of the Mississippi.

In an essay, still unpublished, but written nearly a year since, based, in part, upon my own personal observations, and in part upon a comparison between these and the numerous insulated descriptions of our rocks, given by various Geologists and travellers, I have attempted, and as I believe, successfully, to trace individually, the formations of our great Pennsylvanian series, south-westward along the mountains as far as Alabama, and also to identify them in their course across New York, and the north-western States, and Canada, to the northern shores of Lake Huron and Lake Superior.

Within the whole of this wide expanse of country, researches will develope, I conceive, but *a single*, though vast group of strata, the successive sediments of one immense ocean, the creations of but one prolonged Geological epoch, commencing almost in the dawn of marine animal and vegetable existence, and terminating with the latest produced deposits of the coal.

Viewing the majestic scale of our formations, and the combined grandeur and simplicity of structure, of the enormous Geological basin which they embrace, we turn with grateful satisfaction, to the peculiar position which Pennsylvania occupies, in this vast area. Lying on the margin of the great secondary basin of the United States, and traversed as it is, for nearly three hundred miles through its centre, by the whole broad belt of the Appalachian or Allegheny chain, in which a system of gigantic anticlinal elevations, brings the entire series of formations, several times in succession to the surface, it holds in combination with western Maryland, middle Virginia and eastern Tennessee, the *key* to the Geology of many of the other States, where but *a part* of the same strata are spread out in a nearly horizontal attitude, and exhibited in but a single belt. But it is especially fortunate as to the part of the Appalachian chain which it includes. Being at the termination of the great mountain axes, which have elevated the strata, it is to the gradual dying out of these undulations towards the north-east, that by preserving the upper deposits from the destructive agency, which has swept them away, in the more disturbed portions of the chain, we possess our Anthracite Coal, one of the most inestimable of all the mineral treasures which nature has bequeathed us. The same Geographical position has placed us, in regard to the great basin, precisely where the general structure of the whole can be best observed; the upper rocks including the coal, not passing out of the State towards the north east, but bending northward, and then suddenly turning westward towards Ohio, at the same time that the middle members of this series sweep outside of these as far as the Mohawk, and returning, are recognized along our northern frontier, while those at the base of the formations are beheld encircling these again, and tracing a yet wider curve to run north-westwardly through Canada, and the region of the upper Lakes. We have thus a clue on the one hand, to nearly the whole Geology of the Appalachian chain south-westward, as far as Alabama, and on the other, to that of the greater part of New York, and the other regions to the north-west and west of us.

I conceive that much valuable information of a practical character will, in the prosecution of the Geological Survey of this State, be derived by paying a vigilant regard to the progress of similar research in other States, the correspondence between whose strata and mineral deposits and our own is so striking. For in accordance with the views above adopted, that all the strata hitherto discovered in the great basin of the United States, above the primary rocks, as high as the coal inclusive, constitute but a single group, of which we have the type, in the Appalachian region of Pennsylvania, developed to an extent nowhere equalled; it must be obvious, that we may render subsidiary to our own researches, the explorations made and making in the same formations, throughout any portion of the widely expanded area to which so large a part of our own Geology appertains.

But the most interesting of all the considerations, connected with our geological position, is the magnificent picture it presents of our resources. Embracing a territory where the upper or coal bearing rocks of the great ancient secondary basin of the continent terminate toward the east and north, the revolutions, which have stripped other States of those treasures, have left us in possession of some of the largest and most richly supplied coal fields of which any country can boast. When we regard their immense extent, comprising either the whole or a part of the area of thirty counties, out of the fifty-four in the State, and the wide range and great thickness of many of the coal seams; and when we contemplate the amazing variety in the character of the mineral itself, showing every known gradation from cannel coal to anthracite, fitting it thus for nearly every possible adaptation in the arts, or as a fuel, and then turn our attention to the geological and topographical *structure* of the regions, affording a ready access to their most secluded districts, we behold such a prodigality of happy circumstances as may well inspire exultation. It is estimated that the anthracite coal, conveyed to market from our mines in the course of the past year, has nearly amounted to *nine hundred thousand tons*, yet this large quantity sinks into insignificance, when we look at what the coal trade, even in the next ten years, is destined to become. If we turn to the southern anthracite basin, the present seat of the most extensive mining operations in the State, we behold a mass of coal measures, nearly sixty miles in length and two in average breadth, having, in the middle, an aggregate thickness of good and available coal exceeding, probably, *one hundred feet*. When we consider that, from this basin and its branches, above 730,000 tons have been sent to market, in the course of the past year, from six districts only: the Nesquehoning, the Lehigh Summit, the Tamaqua, the Pottsville, the Pine Grove and the

Wiconisco mines; and when we reflect, that nearly all this coal has been taken from the strata above the water level, below which hundreds, nay thousands of feet of coal, following the dip of the seams, lie still untouched, we are made aware of the enormous amount of undeveloped resources in this coal region alone. The valuable mines of Tamaqua, Pine Grove and Wiconisco are only waiting for greater facilities of access to the important markets on tide navigation, on the Delaware and Chesapeake, to augment by a large amount the annual supply.

The Beaver Meadow, Hazleton and contiguous basins bid fair from the quantity, quality and admirable position of their coal, to become, also, on a large scale, successful contributors to our growing coal trade.

The inexhaustible possessions of the Mahonoy or Shamokin basin, one of the richest and largest of all the Anthracite coal fields of the State, are hardly yet developed; but so soon as the contemplated outlets are completed, the resources of this single valley, in which much of the coal is of very superior quality, will be acknowledged to form a most important item in the mineral wealth of Pennsylvania.

To all these deposits, let us add the vast supplies of coal which fill the large and beautifully constructed basin of Wyoming and the Lackawanna. Here again, when we regard the excellence of the coal, its great abundance, and the admirable position of the region, with a choice of outlets and a boundless market toward the north, we are struck with astonishment at the prospect.

The awakening spirit of enterprize, which is beginning to appreciate the riches of our numerous coal fields, is also directing itself, in part, to the other great mineral staple of the State—our iron ore.

Few regions of similar extent in any country possess this invaluable mineral in the quantity and variety under which it exists in Pennsylvania. To say nothing of the abundance of the admirable pipe ores of our limestone valleys, or the equally profuse supply of rich argillaceous ore in the bituminous coal measures west of the Allegheny mountain, and viewing merely the numerous belts of the brown calcareous or fossiliferous ore of our fifth formation, what a picture of wealth does this alone present to stimulate to the cultivation of the useful manufacturing arts, the active industry of our citizens.

But it is when we consider our various kinds of ore and of coal, under one view, and dwell on their contiguity, their valuable adaptations to each other, and then their exhaustless abundance, that we acknowledge with what a lavish, yet studeous hand, nature has scattered these two great sources of power, prosperity and wealth through Pennsylvania.

CONCLUDING REMARKS.

In my first annual report I made allusion to the glaring defectiveness of the present State map of Pennsylvania, drawing attention to the impediments which its gross errors place in the way of accurate geological investigation, and mentioning the impracticability of delineating, with any approach to truth, the boundaries of the strata, and the position of their mineral deposits after research has ascertained them. In the parts of the State to which the examinations of the survey, during the past year, have been more particularly confined, the topography of the map appears to be especially erroneous; a fact to be the more lamented, as great advantages would arise to the anthracite regions of the State, were it practicable to exhibit upon the map an exact representation of the intricate features of this highly important division of our geology.

Should the Legislature, at some future day, provide for the construction of an accurate map of the State, by instituting a Trigonometrical and Topographical Survey, the results would be fraught with extensive benefits to almost every branch of public and private enterprize, and would reflect lasting credit on the practical wisdom of Pennsylvania.

All which is respectfully submitted.

HENRY D. ROGERS.

Philadelphia, January 27th, 1838.

GLOSSARY

OF THE GEOLOGICAL AND OTHER SCIENTIFIC TERMS EMPLOYED IN THIS REPORT.

Extracted from Lyell's Principles of Geology.

Alluvium.—Earth, sand, gravel, stones, and other transported matter, which has been washed away and thrown down by rivers, floods, or other causes, upon land not *permanently* submerged beneath the waters of lakes or seas. *Etym. alluo*, to wash upon.

Anticlinal Axis.—If a range of hills, or a valley, be composed of strata, which, on the two sides, dip in opposite directions, the imaginary line that lies between them, towards which the strata on each side rise, is called the anticlinal axis. In a row of houses with steep roofs, facing the south, the slates represent inclined strata, dipping north and south, and the ridge is an east and west anticlinal axis.

Argillaceous.—Clayey, composed of clay. *Etym. argilla*, clay.

Bitumen.—Mineral pitch, of which the tar-like substance which is often seen to ooze out of the Newcastle coal when on the fire, and which makes it cake, is a good example. *Etym. bitumen*, pitch.

Bituminous Shale.—An argillaceous shale, much impregnated with bitumen, which is very common in the coal measures.

Calcareous Rock.—Limestone. *Etym. calx*, lime.

Calcareous Spar—Crystallized carbonate of lime.

Carbon—An undecomposed inflammable substance, one of the simple elementary bodies. Charcoal is almost entirely composed of it. *Etym. carbo*, coal.

Carbonate of Lime.—Lime combines with great avidity with carbonic acid, a gaseous acid obtained fluid when united with water; and all combinations of it, with other substances, are called *Carbonates*. All limestones are carbonates of lime, and quick lime is obtained by driving off the carbonic acid by heat.

Carboniferous.—A term usually applied, in a technical sense, to an ancient group of secondary strata; but any bed containing coal, may be said to be carboniferous. *Etym. carbo*, coal, and *fero*, to bear.

Chert.—A silicious mineral, nearly allied to calcedony and flint, but less homogeneous and simple in texture. A gradual passage from chert to limestone, is not uncommon.

Coal Formation.—This term is generally understood to mean the same as the Coal Measures. There are, however, "coal formations" in all the geological periods, wherever any of the varieties of coal form a principal constituent part of a group of strata.

Conformable.—When the planes of one set of strata are generally parallel to those of another set which are in contact, they are said to be conformable.

Conglomerate, or Puddingstone.—Rounded, water-worn fragments of rock or pebbles, cemented together by another mineral substance, which may be of a silicious, calcareous, or argillaceous nature. *Etym. con*, together, *glomero*, to heap.

Crop Out.—A miner's or mineral surveyor's term, to express the rising up, or exposure at the surface, of a stratum or series of strata.

Crystalline.—The internal texture, which regular crystals exhibit when broken, or a confused assemblage of ill-defined crystals. Loaf-sugar and statuary-marble, have a *crystalline* texture.—Sugar-candy and calcareous spar, are crystallized.

Denudation.—The carrying away by the action of running water of a portion of the solid materials of the land, by which inferior rocks are laid bare. *Etym. denudo*, to lay bare.

Diluvium.—Those accumulations of gravel, and loose materials, which, by some geologists, are said to have been produced by the action of a diluvian wave or deluge, sweeping over the surface of the earth. *Etym. diluvium*, deluge.

Dip.—When a stratum does not lie horizontally, but is inclined, the point of the compass towards which it sinks, is called the dip of the stratum, and the angle it makes with the horizon, is called the angle of dip or inclination.

Encrini, (plural of encrinus.)—Marine animal bodies, having a long jointed stem, the joints somewhat resembling small buttons, with a central perforation. These abound in the lower secondary rocks.

Fault, in the language of miners, is the sudden interruption of the continuity of strata in the same plane, accompanied by a crack or fissure, varying in width, from a mere line, to several feet, which is generally filled with broken stone, clay, &c.

Ferruginous.—Anything containing iron. *Etym. ferrum*, iron.

Formation.—A group, whether of alluvial deposits, sedimentary strata, or igneous rocks, referred to a common origin or period.

Fossil.—All minerals used to be called fossils, but geologists now use the word only to express the remains of animals and plants found buried in the earth. *Etym. fossilis*, anything that may be dug out of the earth.

Gneiss.—A stratified primary rock, composed of the same materials as granite, but having, usually, a larger proportion of mica, and a laminated texture. The word is a German miner's term.

Gypsum.—A mineral, composed of lime and sulphuric acid, hence called also *sulphate* of *lime*. Plaster and stucco are obtained, by exposing gypsum to a strong heat. It is found so abundantly near Paris, that Plaster of Paris is a common term in this country, for the white powder of which casts are made.

Laminæ.—Latin for plates ; used in geology, for the smaller layers, of which a stratum is frequently composed.

Mica.—A simple mineral, having a shining silvery surface, and capable of being split into very thin elastic leaves, or scales. It is often called *talc* in common life, but mineralogists apply the term talc to a different mineral. The brilliant scales in granite, are mica, *Etym. mico*, to shine.

Organic Remains.—The remains of animals and plants (*organized* bodies) found in a fossil state.

Oxide.—The combination of a metal with oxygen; rust is oxide of iron.

Oxygen.—One of the constituent parts of the air, or the atmosphere; that part which supports life. For a further explanation of the word, consult elementary works on chemistry.

Producta.—An extinct genus of fossil bivalve shells, occurring only in the older secondary rocks. It is closely allied to the living genus Terebratula.

Pyrites.—(Iron.)—A compound of sulphur and iron, found usually in yellow shining crystals, like brass, and in almost every rock stratified and unstratified. The shining metallic bodies, so often seen in common roofing slate, are a familiar example of the mineral.

Quartz.—A German provincial term, universally adopted, in scientific language, for a simple mineral composed of pure silex, or earth of flints: rock-crystal is an example.

Sandstone.—Any stone which is composed of an agglutination of grains of sand, whether calcareous, silicious, or of any other mineral nature.

Seams.—Thin layers, which separate two strata of greater magnitude.

Secondary Strata.—An extensive series of the stratified rocks, which compose the crust of the globe with certain characters in common, which distinguish them from another series below them, called *primary*, and from a third series above them, called *tertiary*.

Shale.—A provincial term, adopted by geologists, to express an indurated slaty clay. *Etym.* German *schalen*, to peel, to split.

Shingle.—The loose and completely water-worn gravel on the sea shore.

Silex or Silica.—The name of one of the pure earths, being the Latin word for *flint*, which is wholly composed of that earth.

Silicious.—Of or belonging to the earth of flint. *Etym. silex*, which see. A silicious rock is one mainly composed of silex.

Stalactite.—When water holding lime in solution, deposits it as it drops from the roof of a cavern, long rods of stone hang down like icicles, and these are called *stalactites.*

Stalagmite.—When water, holding lime in solution, drops on the floor of a cavern, the water evaporating leaves a crust, composed of layers of limestone: such a crust is called *stalagmite,* in opposition to *stalactite,* which see.

Strata, Stratum.—When several rocks lie like the leaves of a book, one upon another, each individual forms a *stratum;* strata is the plural of the word. *Etym. Stratum,* part of a Latin verb, signifying to strew or lay out.

Strike.—The direction or line of bearing of strata, which is always at right angles to their prevailing dip.

Synlinical axis.—When the strata dip in opposite directions *towards* a common central imaginary line, it is called a synclinical line, or axis.

Thin out.—When a stratum, in the course of its prolongation in any direction, becomes gradually less in thickness, the two surfaces approach nearer and nearer; and when at last they meet, the stratum is said to thin out, or disappear.

Zoophytes.—Corals, sponges, and other aquatic animals allied to them, so called because, while they are the habitation of animals, they are fixed to the ground, and have the forms of plants. From two Greek words, signifying animal and plant.

THIRD ANNUAL REPORT

ON THE

GEOLOGICAL SURVEY

OF THE

STATE OF PENNSYLVANIA.

BY HENRY D. ROGERS, *STATE GEOLOGIST.*

READ IN SENATE, FEB. 19, 1839.

HARRISBURG:
PRINTED BY E. GUYER.
....
1839.

SECRETARY'S OFFICE,

Harrisburg, February 19, 1839.

SIR:—I have received the third annual report of the State Geologist, which is herewith transmitted, in compliance with the acts of Assembly on the subject of a Geological survey of the state.

And am, respectfully,

FR. R. SHUNK,

Secretary of the Commonwealth.

HON. CHARLES B. PENROSE,

Speaker of the Senate.

REPORT.

To the Secretary of the Commonwealth of Pennsylvania:

SIR:—I beg leave to transmit through you to the Legislature, the following report of the operations of the Geological survey of the State during the past year.

In accordance with the views set forth and adopted in my two preceding annual reports, I shall confine myself to an account of the progress which has been made in the field explorations and other work of the survey, and to a general description of the parts of the State which have recently been under examination, intending to reserve, as heretofore, the principal portion of the details collected, with a view of submitting them to the public in a more useful and intelligible shape, in a final and comprehensive description of our mineral resources at the close of the investigation.

The requisite time will thus be gained for completing the maps and the numerous illustrative drawings, some of which are now in hand and will be found indispensable to a full and clear understanding of our Geology. Until this species of illustration, so indispensible to a correct idea of the innumerable local details involved in a complete delineation of our formations, can be presented, the most copious descriptions must fail to impart more than a very inadequate and erroneous notion of many intricate and curious features connected with the distribution of our strata, and the situation and range of their contained mineral deposites. Between the season, when the specimens of ores and other materials collected for analysis are gathered in, and the period for presenting the annual report on the survey, the interval is too brief for completing the chemical examinations which are so necessary to a thorough knowledge of their economical value; and this constitutes another reason for omiting numerous minute local references which would possess but half their usefulness if unaccompanied by a statement of the chemical composition of the various substances met with.

CHAPTER I.

OF THE SECTIONS OF THE STATE WHICH HAVE BEEN EXPLORED DURING THE PAST YEAR.

With a view to expedite the Geological survey as far as compatible with accuracy, in the determinations, and for the purpose of giving to all districts of the State alike, the advantages of an early examination, the last Legislature authorized an increase in the number of assistants in the corps, adding six assistants, and a draughtsman. But little delay has been incurred in procuring individuals of requisite talents to fill the places thus created, and when the spring was sufficiently opened to permit a renewal of our investigations in the field, the corps of assistants was complete, with the exception of two whose services were secured after the lapse of a few weeks.

It now embraces in all, nine Geological assistants, four of whom, namely, Messrs. HARVEY B. HOLL, ALEXANDER M'KINLEY, CHARLES B. TREGO and JAMES D. WHELPLEY, hold their places under former acts; the other five, namely, JAMES T. HODGE, Dr. JACKSON, JOHN C. M'KINNEY, PETER W. SHAEFFER and TOWNSEND WARD, having been appointed under the recent law. There are moreover two chemical assistants, Dr. ROBERT E. ROGERS, appointed under the first act, and MARTIN BOYE, under the late one.

Greatly aided in my plans for a speedy and general exploration of the State by this important addition to the number of my assistants, I proceeded without delay, to re-organize the operations of the survey so as to extend our investigations to various districts not before examined, and to explore in detail a much larger territory than could have been submitted to observation with the limited number of assistants previously employed, and what must be considered as of equal consequence, to impart to the developments which are made, a proportionably increased degree of minuteness and accuracy.

Previously, our researches had been chiefly confined to one district of the State, namely, that which is included between the South mountain, and the foot of the Allegheny mountain, and between the Susquehanna and the Delaware rivers, being directed more particularly to the minute investigation of the several anthracite coal fields.

Encouraged, however, by the additional aid provided by the Legislature, I have distributed the corps, as far as practicable, over the whole State, assigning a different district to each person, or to two together as the extent and intricacy of the region, or the limited number of the assistants suggested. Accordingly, the whole surface to be explored, was divided into six districts, naturally separated by tolerably well marked boundaries, both Geographical and Geological.

The *first* of these divisions includes all the counties lying south and east of the Kittatinny valley, embracing Philadelphia county, Delaware, Bucks, Montgomery, Chester, Lancaster, York, Adams, and parts of Lehigh, Berks and Dauphin counties. Mr. Holl has assisted in the investigation of part of this region, lying between the Schuylkill and Susquehanna rivers, while Mr. Boye aided me, during a part of the season, in the country lying between the Schuylkill and the Delaware. The counties of York and Adams were not embraced in the operations of the season, nor was it in our power to traverse more than about one half of the other counties enumerated.

The *second* district comprises the north-eastern part of the Appalachian region of the State, or all that part of our territory which is embraced between the north-western base of the South mountain and the south-eastern base of the Allegheny mountain, and between the Delaware and Susquehanna rivers, terminating on the latter at Muncey creek. This district, the seat of the operations of the previous year, had already received a considerable share of investigation, though the amount of time devoted to it had been insufficient for that detailed and thorough examination of the several anthracite basins which these obviously require, both from their pre-eminent public importance and from the minute and intricate relations of their numerous beds of coal. It was deemed advisable, therefore, to continue the work of developing these coal basins, with as large an amount of assistance as the claims of the several other quarters of the State would justify I accordingly devolved the important task of exploring the south-eastern and middle coal regions to Mr. Whelpley, aided by Mr. Shaeffer, who were facilitated in executing numerous detailed measurements by competent surveyors, whose services were procured for the occasion.

It is conceived, however, that at least another year will be required before a multitude of local points of structure, still obscurely understood and upon a precise knowledge of which the successful tracing of the coal must much depend, can satisfactorily be made known.

The south-western half of the Appalachian region, or that included between the Susquehanna river and the state line of Maryland, and between the South mountain and the Allegheny mountain, constitutes our *third* Geological sub-division of the State, and presents in its complicated topography, and in the numerous rich deposites of iron ore distributed over many of its curiously constructed valleys, a wide field for investigation, requiring close and patient research. The assistants who have been aiding me in the investigation of this difficult region, are Mr. M'Kinley and Dr. Jackson, who, during the season, have explored in detail nearly all of that part of the district which includes portions of the counties of Union, Lycoming and Centre.

That important half of the State which is bounded on the south-east by the main ridge of the Allegheny, on the north by the State of New York, and on the west by Ohio, embracing nearly all the bituminous coal fields of Pennsylvania in a series of closely connected basins, was also sub-divided into three districts. These, however, are less distinctly separated by their Geological structure and resources than the division before traced. One of the districts alluded to, which I shall call the *fourth* in the State, takes in the whole country between the base of the Allegheny mountain on the south-east and Chesnut ridge or west Laurel Hill on the north-west, extending from the Maryland state line to the Bellefonte and Brookville road. In the arduous task of exploring this very interesting, but wild and forest country, I devolved the details of the examinations upon Mr. Trego, who was aided by Mr. Ward. A large portion of the southern half of this region has been explored, probably with as much minuteness as the wild and wooded character of the surface would permit, while other sections, especially the northern half, will demand a considerable amount of additional research, before a sufficiently clear view of the situation and extent of the mineral wealth of the district can be acquired.

The *fifth* district comprises nearly all the counties lying west of Chesnut ridge, and of a line prolonged north from its northern extremity along the eastern county line of Armstrong and Venango, and thence through Warren to the state line of New York. In order to secure as speedily as possible a developement of this part of our

State so highly endowed in its Geological resources, I divided it for the season into two sections, assigning to Mr. M'Kinney the duty of aiding me in exploring the southern half and to Mr. Hodge the same duty in regard to the northern portion. In that portion of the district lying south of the Allegheny and Ohio rivers, about one half of the data necessary to a thorough understanding of its economical geology or useful mineral resources have been collected, while, throughout the rest of this extensive western region, a rather less degree of progress has been made, in consequence of my not procuring the services of Mr. Hodge until the two first months of the season had elapsed.

The *sixth* and last division of the State, includes all those parts of Luzerne, Lycoming and Centre counties, which lie north or northwest of the base of the Allegheny mountain; also the northern two-thirds of Clearfield and Jefferson, the eastern half of Warren, and the whole surface of M'Kean, Potter, Tioga and Bradford counties.

The five large sections of the State previously enumerated, engrossed the attention of all the assistants in the survey and a very large share of my own time, the remaining portion of which was spent in parts of the region last designated. It was not practicable, therefore, to undertake during the season a regular survey of the extensive counties in the northern part of the State, which, throughout more than four-fifths of its surface, is an unbroken wilderness, requiring for the examination of its little known, but inexhaustible resources, a party specially equipped with tents and other accommodations for subsisting in and traversing its dense forests. The extent of my observations in this quarter of the State, has consisted in a personal reconnoisance made during a few weeks in parts of Warren, M'Kean, Jefferson, Clearfield and Centre counties, with a view of ascertaining the best mode of overcoming the peculiar difficulties which the wilderness character of the region presents to accurate Geological researches, and of planning for the future seasons of the survey a systematic exploration of its well-stored coal fields. Enough was discovered of the Geological structure and peculiar topography of this portion of country, to enable me to determine the most eligible method of conducting a detailed examination, and to authorize the conviction, that the real extent and position of its mineral wealth can be satisfactorily ascertained, within a period as brief as will be wanted for the survey of the other districts of the State.

Many reasons suggested the propriety of distributing the corps of assistants in the manner above designated. It was desirable to afford to every part of the commonwealth, as far as practicable, the advantages of an early survey of its own peculiar mineral resources, and a simultaneous exploration of several districts is obviously the only mode by which, in a limited number of years, the requisite degree of precision can be attained. Each district has a more or less different class of deposites disposed in a special order, not to be witnessed elsewhere; it has also a different topography, which when adequately studied affords oftentimes a valuable clue in tracing its mineral deposites; while, on the one hand, it has its peculiar difficulties that demand much local knowledge to surmount, and on the other, features calculated to lead to useful discoveries, if familiarly understood. By allotting, therefore, a particular range of country, as far as possible, to each individual in the corps, and restricting his explorations to that alone, until he shall have mastered its geology and mineral resources in all their local details, an important economy of time is effected, and increased accuracy in the results is insured.

Having adopted this system, my own duties have consisted in visiting every district several times in the season, in regular rotation, and in personally superintending the explorations as they proceeded. This plan tends to remove the difficulties in the investigation as they arise, by contributing the experience and information gained in the other quarters of the State to any particular case to which they may apply. It enables me also, without loss of time, to institute when necessary a fresh series of measurements, or if the work be much retarded by local intricacies, such as occasionally occur, to concentrate an increased number of assistants to the point. While thus superintending and directing these investigations, I deem it my duty to review in person every portion of the field explored, which possesses the least share of practical or scientific interest; so as to be able, while checking the results of the assistants, to satisfy myself by personal observation of the facts and conclusions with which they continually furnish me.

CHAPTER II.

A GENERAL SKETCH OF THE OPERATIONS OF THE SURVEY IN THE DISTRICTS SOUTH-EAST OF THE ALLEGHENY MOUNTAIN.

SECTION 1.

Of the first or south-eastern district, embracing the country lying to the south-east of the Kittatinny valley.

The south-eastern or first district in the foregoing Geological division of the State, comprehends all the region which lies to the south-east of the great limestone belt which ranges through the Kittatinny or Cumberland valley, or in other words, it is bounded on the north-west by the north-western base of the chain of hills called the South mountain. The rocks which appertain to this populous and highly favored section of our State are of several descriptions, as follows: each presenting several varieties and embracing minerals of more or less utility and interest. First, various species of the so called primary stratified rocks, as gneiss, mica slate, talc slate, crystalline limestone or marble, serpentine, &c.

Secondly, unstratified crystalline rocks of undoubted igneous origin, as granite and sienite, both of them usually in thin veins, and also greenstone, basalt and other species of trap rock penetrating and overlapping the primary and secondary strata in dykes and ridges of considerable magnitude.

Thirdly, rocks of sedimentary origin of the class called secondary. Some of these claim identity with the lower formations of the great Appalachian series of strata, more fully developed throughout the rest of our State, to the north and west of the South mountain, while others belonging to deposites of a somewhat more modern era, their materials having been brought together after the strata, embracing all our coal seams, were upheaved to form part of the dry land. Of the former are the sandstones designated as formation No. I, of our Appalachian series; these compose a considerable portion of the rocks of the South mountain. Next the limestones or formation II, of the same series; these occupy nearly all the central tracts of Lancaster county. Lastly, the slats of formation III, identical with the slate rocks of the north-west side of the Kittatinny valley, but confined in this district to a few small valleys subordinate to the chain of hills in that part of the range which is east of the Schuylkill river.

The other group of secondary rocks in this district composes red shales, and red and grey sandstones, and several varieties of conglomerate, all belonging to one series of deposites of a date posterior to the coal, and occupying a long and irregular trough extending across the State from Maryland to New Jersey, through the counties of Adams, York, Dauphin, Lebanon, Lancaster, Berks, Chester, Montgomery and Bucks. To these rocks I propose to give the name (for convenience sake) of *middle* secondary strata, in contradistinction to the Appalachian formations on the one hand, which are unequivocally our lowest secondary formations, and on the other hand to the green sand deposites of New Jersey, Delaware and some of the southern states which constitute the uppermost secondary strata of our country.

The primary rocks of Pennsylvania, which are confined exclusively to this south-eastern division of the State, are spread over a very limited area, probably not exceeding one-fifth of the surface of the district. They extend in two distinct and narrow belts from the Delaware river to the Maryland state line, occurring in the south-eastern tract in one continuous range, but appearing in the north-western one only in insulated patches in the chain of hills called the South Mountain.

The more southern of these belts commences at a spot in New Jersey about six miles north-east of Trenton, where the primary rocks emerge from beneath the overlapping red strata of the middle secondary series. Commencing in a narrow point, they gradually expand in width as they range south-westward along the southern border of the State and the adjacent parts of Delaware and Maryland. The south-eastern margin of these primary rocks crosses the Delaware river a little below the bridge at Trenton, and passes by Bristol, Philadelphia, Chester and Wilmington, keeping parallel with the general course of the river, separated from it by a narrow fringe of overlapping diluvial and alluvial deposites of rarely more than a single mile in width. The northern margin, commencing at the same point in New Jersey, crosses the Delaware about a mile and a half above Trenton, and stretches in a somewhat undulating line south of west so as to meet the Schuylkill about two miles below Norristown and the Susquehanna at Turkey Hill, below Columbia. Between the Susquehanna and the Maryland state line, its course is rather more south-westerly.

The long wedge-shaped tract here delineated, has not as yet been traversed with a view to that minute and systematic examination which it demands. It offers for Geological exploration many useful and interesting materials, among which are belts of gneiss and sienitic trap rock for building, with a formation of crystalline marble in much request for the higher purposes of architecture, besides many exposures of serpentine beds of whetstone and localities of valuable and curious minerals, such as the ores of iron, manganese and chrome. The investigation of the Geology of this belt of country and its mineral contents, will form a part of the business of the survey during the approaching season. The primary rocks of the South mountain show themselves principally in the part of the chain which lies between the Delaware and Schuylkill rivers. They are largely developed throughout all that portion of the same range of hills which crosses New Jersey and New York under the name of the Highlands, but they gradually disappear in going south-westward after we enter Pennsylvania, especially as we approach the Schuylkill.

Between the two above mentioned rivers, the South mountains contain both the primary rocks and the lowermost formations of our lower secondary or Appalachian series, or in other words, the sandstone which I have designated in my last annual report as formation No. I, the limestone, formation II, and a little of the slate, formation III; west of the Schuylkill, there is an insulated tract of primary rocks occupying an area of about nine miles in length by two and a half in width, commencing at a point about seven miles west of Reading and ranging along the southern side of Millbough hill, through a small part of Berks and the adjacent corners of Lancaster and Lebanon.

There are a few other very limited patches of the primary rocks, confined generally to the summits of the sandstone ridges through which they seem to have been protruded by the agency of those subterranean forces of elevation, which have lifted up those hills and tilted their strata into the inclined attitudes in which we behold them. Some of these occur in the chain between Allentown and Reading. That part of the South mountain which lies between Adams and Franklin counties, and which is a prolongation of the Blue ridge of

Virginia, embraces a far larger proportion of primary rocks, but its Geology and Mineralogy have not yet been examined; the exploration of those counties in the district, which lie south-west of the Susquehanna, having been unavoidably deferred until the coming season.

Iron ores in the primary rocks of the South mountain.

Crytaline magnetic iron ore accompanies the gneiss rocks of the South mountains in our State in several places, though the veins are much less frequent and extensive than in the same formation in New Jersey. At Durham, on the Delaware, it exists in considerable quantity, to all appearance in the form of regular veins of injection, but these mines have not been wrought for many years.

At Mount Pleasant, in Colebrookdale township, Berks county, the ore is extensively excavated. It would appear to lie in beds, or rather in regular veins, and to be in truth, the magnetic ore of igneous origin, in a rotten and decomposed condition.

Between the northern margin of the southern tract of primary rocks, and the Kittatinny valley, nearly the whole surface, with the exception of limited patches of primary strata in the South mountains, comprehending most of the hills of that chain, and the wide plains spreading southwards from them, consists of the two great formations at the bottom of our lower secondary series and the overlying red rocks of the middle secondary group.

SANDSTONE FORMATION NO. I.

The white and grey sandstone (formation I,) which is the lowermost of the two former, occurs abundantly in the South mountains from the neighborhood of Allentown to the Schuylkill at Reading. In Northampton and the eastern corner of Lehigh, the sandstone, though occasionally met with on the flanks of the hills, is subordinate in importance to the gneiss and other primary rocks upon which it rests; but in Earl township, Berks county, it forms most of the higher hills. Between the Schuylkill and Susquehanna rivers this rock is largely developed in several ridges; it forms the mass of Millbough hill near Womelsdorf, reposing upon the gneiss rocks that lie to the south and sustaining in its turn the limestone strata of the Kittatinny valley. The relative portions of these three formations are here well exposed It entirely covers the flanks and the summit of the ridge called the Welch mountain, in the eastern corner of Lancaster and the adjacent parts of Chester counties. This uplifted belt commences about three and a half miles east of Morgantown, and terminates a little south of New Holland, having a length of about fifteen miles. On the south it lies upon the gneiss, the line of junction between the two rocks following the foot of the ridge, while on the north it is covered by the limestone which overlaps it to the very base of the hill. West of Churchtown, in Lancaster county, the sandstone has been brought to the surface, through the overlying limestone strata, in a little insulated hill, about one mile in length, and it forms another very similar low ridge of about the same dimensions near Neffsville, where its strata dip away in opposite directions from the summit of the hill, forming thus an anticlinal axis, as it is termed, along its centre. Again, in the western part of Lancaster county, this sandstone has been protruded through the limestone in the form of a bold ridge of hills which crosses the Susquehanna between the towns of Columbia and Marietta. The most eastern exposure of the rock in this tract, is near the village of Hempfield, three and a half miles from Lancaster, from whence the northern border of the stratum extends northward for about a mile to the White Horse tavern, and thence sweeps westward and southwestward, following up the valley of Kauffman's run, from which it stretches nearly westward to the mouth of the Chickasalungo creek. Its southern edge passes the village of Mount Pleasant, whence it extends with but little undulation to the Susquehanna, which it crosses not far above the bridge at Columbia. A little below that town, and also at Marietta, the sandstone beds are seen alternating with the lower strata of the next superior rock, the limestone (formation II,) exhibiting a southern dip at the former place and a northern one at the latter. Some of these upper alternating beds of the sandstone, graduate into a material which is in some places nearly a pure slate; in the bold exposure of this formation on the Susquehanna, we behold abundant evidences of the change which this rock has undergone in its texture from the heating action of the veins of quartz which have been injected into it from below. Some of these veins of quartz bear a marked analogy to those which, in the southern states, contain the gold, a resemblance which has excited hopes from time to time that this enticing metal might really be present in some quantity within our State. But a careful analysis of the most promising specimens, not only from the locality on the Susquehanna, but from several others in York, Lancaster, Chester and Berks counties, has assured me that any dreams of riches from such source must prove wholly delusive, no appreciable quantity of the metal having been hitherto detected. The copper mine ridge consists throughout the chief part of its length of this sandstone formation, and some of the hills bordering the western part of the limestone valley of Chester county on the north, would appear to contain the same rock. But this belt of country near the southern primary range has not yet been minutely traced.

Iron Ore.

This lowermost stratum of our secondary series is occasionally the repository of very valuable collections of iron ore, one very extensive and rich deposite of which occurs upon it on Chesnut hill, about four miles from Columbia. It lies in a basin-shaped depression in the rock and is sometimes confusedly mixed with sand, clay and steatitic matter, and sometimes lies surrounded by a less proportion of foreign matter in nearly horizontal beds. Large bodies of similar ore, technically termed the brown argillaceous iron ore, are associated with this sandstone or appear at least to have been derived from it, in several places near the South mountain chain, especially along the southern side of the Kittatinny valley, in Lehigh, Northampton and Lebanon counties. A little iron ore has been found in it in the Welsh mountain near the turnpike, but not in sufficient quantity to be valuable.

LIMESTONE FORMATION MO. II.

Resting upon the sandstone just described, the next formation in the ascending order is the valuable blue limestone stratum which occupies nearly one-half of the entire area of Lancaster county. This is the same rock with that which was described in my last annual report, as extending along the southern side of the Kittatinny valley, throughout its whole length, and which is there designated as formation II, in our Appalachian system of strata. It covers a large and important tract in the district south-east of the Kittatinny valley, spreading over the broad and fertile plain which extends in an east and west direction through the central townships of Lancaster and York counties. The eastern limit of this great expanse of limestone is about three miles east of Morgantown in the southern corner of Berks county. Its south-eastern margin extends from thence along the northern base of the Welch mountain, which it follows to its western end, near New Holland, in contact with its white sandstone. There the limestone doubles round the end of the ridge and spreads eastward through the southern half of Salisbury township into Chester county. From Chester county, the southern limit of this rock follows, first the northern base of the Mine hill as far as Strasburg township, after which it courses along the foot of a chain of low hills in the same westward prolongation to the Conestoga creek; it then descends along the valley of this stream as far as the north-eastern foot of Turkey hill, around the various spurs of which it winds until it reaches the Susquehanna river at the mouth of Wister's run. Throughout this course the limestone lies in contact either with the sandstone (formation I,) or with the gneiss or talc slate rocks of the primary class. The northern margin of the limestone starting at the same point near Morgantown, ranges westward across Lancaster county in a somewhat undulating line to the Susquehanna, which it crosses immediately above the village of Bainbridge. Lying to the north of this large expanse of limestone, and separated from it by a long tongue, as it were, of the red rocks of the middle secondary series, are two other valleys of the limestone, the eastern one containing the waters of the Cocalico creek, and the western one the Moravian towns of Litiz and Manheim. The limestone along its whole northern limit, between Morgantown and Bainbridge disappears beneath the overlapping strata of red sandstone of the middle secondary series, the beds of which may be seen resting upon it in an *unconformable* position, having generally a dip toward the north at an angle of from fifteen to twenty-five degrees. There is evidence that these newer or middle secondary rocks once spread themselves southward over the limestone much more extensively than at present, the destructive agency of a heavy current of waters having removed a large tract of the uppermost formation. To the same action we may refer the peculiar bench or terrace which the overlying red sandstone uniformly presents along its margin rising from thirty to forty feet above the plain occupied by the limestone. The removal of the upper rocks at a point about four miles west of Manheim has laid bare a small and narrow patch of limestone upon Chickasalungo creek, not much exceeding half a mile in length.

This valuable formation likewise shows itself in a few confined valleys subordinate to the South mountain, in the neighborhood of the Delaware and Lehigh rivers; one of these tracts ascends the valley of Durham creek from its mouth as far as Springtown, the calcarious rocks showing themselves even to the west of the Hellerstown road; another belt of it pursues the valley of Saucon creek to its very head, almost two miles north-east of Shimersville. A narrow strip of the same rock is seen along the Little Saucon creek for about three miles above its mouth. Further towards the south-west the limestone is less abundant, being seen only in small and detached exposures. It occurs thus in several localities in Upper Milford township, Lehigh county, and in Hereford township, Berks county, as far as the point where the chain of hills divides. The valley here formed, constitutes parts of Oley township, which consists of the limestone in the eastern and southern part, and of the overlying slate (formation III,) in the northern and western part. The limestone also occurs at intervals along the northern margin of the red sandstone. In some of these exposures, as in Douglass township, the limestone is seen in immediate contact with the overlying red sandstone, and in several neighborhoods, as for example, at the south base of Neversink hill below Reading, the very singular, coarse, variegated conglomerate which in this part of the State forms the uppermost bed of the middle secondary group, may be seen dipping directly against the highly inclined strata of the limestone.

MIDDLE SECONDARY RED SANDSTONE FORMATION.

We come now to the red sandstone formation which stretches through the central and northern portions of our south-eastern district in a long and irregular tract from New Jersey to Maryland. As a group of rocks, this is one of the most remarkably uniform in respect to its materials and appearance, in our country. It consists of dark reddish brown sandstones, almost invariably argillaceous, of soft crumbly brown shales and coarse conglomerates, frequently of very heterogeneous composition. The prevailing, we might say the almost invariable direction of the dip of these strata is towards the north at angles varying from fifteen to twenty-five degrees. The lower beds, or those which show themselves along the southern edge of the tract, consist most frequently of rather coarse sandstones alternating with red shales, the sandstones being formed of somewhat angular fragments of quartz, felspar and other ingredients of the neighboring primary rocks, cemented by a paste of brown argillaceous matter. The central parts of the formation consists more exclusively of brown shales and brown argillaceous sandstone, while the uppermost beds, occurring along the northern margin of the formation, have frequently the character of coarse conglomerates, made up of pebbles derived from a very great variety of rocks, chiefly those which occur at the base or on the sides of the adjacent hills of the South mountain chain. Where a large proportion of the pebbles are of limestone and the cementing red earth which unites them contains an adequate quantity of the same materials, the rock possesses the character of a marble, being susceptible of a good polish and resembling certain highly variegated breccias.

Of this character are the beds of this rock near the Potomac river, which furnished the columns in the House of Representatives and the Senate chamber of the Capitol at Washington. The same rock occurs in the vicinity of Reading, and at many other places along the same line, crossing our State, and in every respect seems equally well fitted for the purposes to which the so called Potomac marble has been applied. The hardness of some of the pebbles and the consequent difficulty of dressing and polishing this rock, will account for its not having been hitherto wrought as an ornamental marble in our State, but it is possible that by a judicious applicatio o f machinery it might be profitably worked.

Though this conglomerate constitutes the uppermost member of the red sandstone group in various places, both in New Jersey and Pennsylvania, there are other neighborhoods, where, for example, near Bainbridge on the Susquehanna, it would seem rather to occupy a position at the base of the series. All these rock of the middle secondary date of which the argillaceous red and brown sandstone is the predominant and characteristic variety, appear from numerous geological indications to have been produced at a period subsequent to the elevation of the lower secondary strata, including the coal deposites. They seem to have originated in a long narrow trough or bay which had its source at least as far south as the central latitudes of Virginia, and which probably opened into the ocean somewhere near the present positions of the Raritan and New York bays.—Their materials give evidence of having been swept into this estuary or great river from the south and south-east, and hence the almost universal dip or inclination of the beds towards the north-west, a feature clearly not produced by any uplifting agency, but assumed originally at the time of their deposition in consequence of the direction or set of the currents, which laid them down layer after layer. With the exception of one or two fossil fishes found in this formation in New Jersey, I am not aware that any animal organic remains have been hitherto met with in any part of the stratum, and hence it becomes difficult to assign its precise place in the general series of Geological formations. Relics of vegetation are, however, occasionally found, especially under the form of highly compact and bituminous *lignite*, the transverse section of which bears no remote resemblance to some kinds of cannel coal, while the longitudinal section exhibits very distinctly the fibrous structure of the wood whence it has been formed. This lignite occurring sometimes in seams of two or three inches thickness amid dark shales, has been a fertile source of delusion; some persons having been induced, by the hope of finding valuable coal mines, to expend both time and substance in the search. All the Geological facts produced during the survey of this formation, discountenance the notion that it contains any coal. It seems to have originated at too late an epoch for the production of coal, the conditions under which its deposites were swept together being apparently inimical to the accumulation of a sufficient quantity of vegetable matter; the detached fragments of plants which we meet with in the form of lignite, having evidently been loosely drifted into these sediments from the land.

The general limits of the red sandstone formation, as far as regards the region between the Delaware and Susquehanna rivers, are as follows: Its southern margin, crossing the river about a mile and a half above the town of Trenton, runs nearly westward to the Schuylkill, passing about two miles south of Norristown; it there extends by Valley Forge and Kimberton to French creek, the course of which it follows nearly to the county line of Chester. It passes about half a mile to the north of Morgantown, Churchtown and Hinkletown, and goes through Millport to Buchanan's run, where it suddenly folds back and runs towards the north-east, through Ephrata to Reamstown. From the last point it sweeps in a regular curve, first towards the north-west and afterwards the south-west, crossing the turnpike at Middle creek. Reaching Hammer creek it descends along the course of this stream to Erb's mill, where it turns again westward, passing about a mile to the north of Litiz, and reaches in the same course Manheim. Here it goes once more towards the east, which direction it pursues as far as Buchanan's run, where, however, it again turns westward, continuing in that course uninterruptedly to Springfield, at which place it makes another short flexure but soon resumes its western range, passing one mile and a half south of Elizabethtown, and thence nearly in a straight line south-westward to Bainbridge on the Susquehanna. From the Delaware river at Trenton to the Warwick mine, near the head waters of French creek, the red sandstone stratum overlaps the gneiss and other rocks of the primary class. From the latter point it ranges in contact with the white sandstone of the Welch mountain, but on entering Berks county and in its course across the whole length of Lancaster county, its southern margin is every where in junction with the limestone. The northern border of this middle secondary formation, beginning at the Delaware near Durham, if traced westward across our district, will be found to pass about one mile south of Springtown and one mile north of Cooperstown to the Hosacock creek, where the road crosses it in Upper Milford township. It then runs a little to the south of Mount Pleasant iron mines, passes Boyerstown, crosses the Perkiomen one mile south of the Black Bear tavern, and meets the Schuylkill about two miles south of the town of Reading. The Potomac marble or calcareous conglomerate occupies several long narrow tracts along the line just traced; one a little below Springtown, another on the Manatawney creek, and a third on the Limekiln creek. It has already been alluded to as occurring on the Schuylkill below Reading. From this latter point, the northern edge of the sandstone stratum extends with a slight undulation in a nearly western direction to the south-western end of Millbough hill, overlapping first the limestone of the Kittatinny valley, then primary rocks, and finally the white sandstone of the hill. From Millbough hill its range is a little south of west, through Sheafferstown, past the Cornwall iron works and thence along the turnpike to Campblestown, from which it takes a nearly straight course to Highspire on the Susquehanna. Between Millbough hill and the Susquehanna, the red sandstone formation lies every where in contact with the limestone of the Kittatinny valley.

TRAP ROCKS.

The red sandstone formation embraces numerous ridges and dykes of trap rock, indeed nearly all of this rock which is contained in our State is confined to the area occupied by that stratum. It occurs principally in the north-eastern half of the tract. The trappean matter brought to the surface in a state of fusion, through the dislocated red sandstone beds, gives frequent evidence of its having had a heat which has entirely changed the character of the shales and sandstones, which have sometimes the aspect and texture of an overbaked brick or tile. The Conewago hills consist of the trap rock in several varieties, both fine grained and coarsely crystalline.

IRON ORE IN THE RED SANDSTONE FORMATIONS.

There are several places in the red sandstone tract, where iron ore exists in greater or less abundance. The three principal localities between the Susquehanna and Schuylkill, are the Cornwall mine in Lebanon county, Jones' mine about three miles from Morgantown in Berks county, and the Warwick mine six miles north-east of the same place on French creek in Chester county. The Cornwall mine is extensive and yields ore of very considerable richness, which, however, contains a small proportion of copper. The mine near Morgantown, though formerly wrought to some extent, is now of comparatively little value. The ore is mixed with carbonate and silicate of copper, the excavation having originally been undertaken as a copper mine. In the Warwick mine the ore is apparently of good quality, but hard. A mixture of this and the previously mentioned ore is said to yield a very good metal. All the three iron mines here enumerated, occur in the red sandstone, but in the immediate vicinity of dykes of trap rock. The ore is manifestly of igneous origin, much of it being crystalline and magnetic, and appears, like the trap, to have been injected into the sandstone in a melted condition.

This proximity of the ore to that rock, suggests the same practical rule for its discovery which applies to the copper ores throughout our State and New Jersey, namely: that we should seek for its external indications either immediately along the base of the trap ridges or within a short distance from them. Similar iron ore occurs in the district between the Schuylkill and Delaware rivers, in the red sandstone. The principal mine in this region is Fegeley's at Boyerstown, not at present in operation, in the vicinity of which there is another mine (Rhodder's) in which the ore is magnetic. Numerous details regarding the ores and other useful materials connected with the red sandstone tract of the State, are reserved unavoidably for the more ample pages of the final report.

The opportunity will then be embraced for introducing many particulars respecting all the various substances of any economical value.

which appertain to the several formations already described, among which are all the iron ores of the South mountain, whether associated with the gneiss rock, the sandstone formation I, or the limestone formation II; also useful building materials, including ornamental marbles, the whetstones of Hereford township in Berks county, and clays for brick making, and whatsoever else may be deemed of practical importance.

SECTION 2.

General sketch of the operations in the second or north-eastern Appalachian district.

The operations of the survey in the north-eastern half of the Appalachian region of the State, have been principally restricted during the past season to our middle and southern anthracite basins; the detailed exploration of which was systematically entered upon in the previous year. Aided in this part of the survey by two of my assistants, who have taken an active part in the examination since its commencement, I have been enabled to carry on, without interruption or change of plan, the investigation of this highly important and intricate region, giving to the work as it advances, such increase of accuracy in its details, as reiterated observations can alone secure in a country possessing its peculiar and complex structure.

For a more full account of the object and the nature of the measurements performed in the course of this investigation, among these several coal basins and their individual seams and strata, I must refer the reader to my second annual report on the survey. I may however state, that our recent researches in this region have been conducted with a view to delineate as accurately as possible, the boundaries of the several coal basins, to ascertain the relative position, and trace the actual range of each of their important beds of coal, and to discover the existence and trace the direction of all important axes of elevation, and all great dislocations by whose agency the strata are displaced from their regular course, and thereby the hopes and labors of the miner too often frustrated.

In order to accomplish these objects, several distinct species of investigation have been resorted to as necessary.

First. The topography of the region has been critically examined, and the essential dependence which exists between even its lesser features and the Geological structure at each place, carefully studied, as necessary to the construction of a *Geological map* of the whole on a large scale, showing the limits of each basin, the position and range of its principal beds, and of the more influential lines of disturbance affecting the strata.

Secondly. The *superficial evidences*, embracing an examination of the external characters and dip of the strata have been systematically collected with a view to show the presence or absence of coal measures, and to identify and trace the several beds.

Thirdly. A series of parallel lines at right angles to the course of the strata, have been *measured* and *levelled*, in order to ascertain more strictly the boundaries of each basin, and the true situation as far as possible of each coal seam, and to detect any increase or diminution in the breadth and probable depth of the former or in the mutual distances of the latter, and to impart additional precision to the sectional drawings, which are to elucidate these points, by procuring correct outlines of the surface.

When it is understood by what invariable relations the Geographical and Geological structure of our Appalachian region are connected together, the necessity for this first preparatory operation, *the construction of a map*, on which to lay down our results, will become obvious. Of those at present in use, the best are well known to be defective, and for Geological researches, where slight variations in the course and shape of the mountain ridges and axes of elevation are found to correspond with important changes in the position and direction of the strata, they may be considered as wholly useless.

Abstaining from all minute and local details referring to particular mines or individual coal beds, as not suited to an annual report, from which the indispensible illustrations of maps and sectional drawings which will accompany my final report are necessarily excluded, I shall confine my remarks on the present occasion, to a description of the position and range of the several leading anticlinal axes of our great southern and middle coal fields; or what is the same thing, to a rapid specification of the approximate boundaries of the coal measures, in the numerous lesser basins or synclinal troughs into which those axes subdivide the whole anthracite region. The information imparted in the few following pages will tend, I trust, materially to aid the examinations of those who are aiming to determine the important question of the existence or absence of coal upon their lands, and if closely attended to, may essentially assist the explorer in ascertaining the true limits of the coal, especially in some of the less known basins. If it should deter even a few from the wasteful expenditures, and many ineffectual enterprises for establishing mines in neighborhoods where the position of those axes, and the appearance at the surface of the lower strata, prove, even without assistance from other Geological evidence, that no coal measures can exist, I shall deem it of more general utility, than any thing in the shape of local details that I could offer in the narrow limits of the present brief report.

In the attainment of this object, combining also careful observations of the soil, the dip and character of the rocks, the position and number of the coal beds and deposites of iron ore, the greater portion of the past season has been occupied. The other portion of our time was employed in the collecting of specimens, the tracing of coal beds, and in more minute observations on the disturbances of the strata, made both on the surface and under ground in numerous tours of inspection, for this purpose, through the mines. In the Beaver Meadow district, two parallel and long lines of levelling have been completed between seven and eight miles apart. One of these measurements was commenced upon the Spring mountain, opposite the town of Beaver Meadow, and carried in a direction north, twenty degrees west, or nearly at right angles to the range of the strata, and made to terminate on Buck ridge six and a half miles distant. The other was commenced upon Buck ridge, opposite the Sugarloaf mountain, and directed south, twenty degrees east, to its termination upon the Spring mountain, near its western extremity.

The coal deposites of the anthracite region admit of a natural and scientific division, into four distinct groups. First in extent, though not at present in importance, we have the great northern basin, extending from a few miles north of Carbondale on the Lackawannock creek to the Knob mountain, where both boundaries of the basin near their south-western junction are broken through by a notch, giving passage to the river Susquehanna. Separated from this basin by the great anticlinal axis of the Wapwallopen hills, by which the rocks of our formations VIII and IX are brought in succession to the surface, we find the eastern or middle anthracite coal field composed of eight narrow basins, lying contiguous to each other and containing the lower coal beds of the series, one of which is of great size and importance.

Cut off from these last by the deep red shale valleys of the little Schuylkill, Catawissa and other streams, but situated nearly in the same range, we have the coal fields of the Mahanoy and Shamokin, composing our next natural group of basins. And lastly, south of all these and separated only by the high anticlinal axis of Broad mountain, lie the Broad mountain, Mine hill and Pottsville coal basins, the last extending eastwardly to Mauch Chunk and westwardly to the neighborhood of Pinegrove, where it divides into two branches, the northern one, under the name of Wisconisco mountain, extending westwardly several miles beyond the county line of Dauphin and Schuylkill, to Lykens' valley; and the other embraced between the Stony mountain, and a continuation cf the Sharp mountain, reaching nearly to the Susquehanna river. From Geological evidences too numerous and striking to be questioned, we infer that all the coal deposites of our anthracite region with their associated rocks, owe their present more or less inclined posture and their limits, to the influence of two grand causes, namely: subterranean elevation and the superficial denuding action of a deluge. Keeping in view the joint operation of these forces, we are enabled to explain as their natural and necessary consequences all those singular positions and complicated disturbances of the coal measures which are so apt to deceive the calculations of the miner, and to elude the researches of those who have adopted their ideas of the structure of all coal basins from the simple forms of the celebrated European coal fields, or the description in elementary books.

As the natural result of the above mentioned cause, we find our anthracite basins connected together into the groups above described. The great stratum of conglomerate rock, formation XII, which is found so remarkably developed in the Sharp and Broad mountains, may be seen underlying every coal field in the region, and indeed points enough of connexion could be traced, which would show the absolute identity of the conglomerate of the Beaver Meadow and Hazleton region, with that of the Mahanoy, and of this again, with that of the Shamokin and Broad mountain troughs, and of the latter with that of the Mine hill and Pottsville basins. Between the conglomerate strata of M'Cauley's mountain and Buck's mountain, and between those of the Buck's mountain and Wyoming mountain, there is a wide interval, but we have ample Geological evidence to prove, that by the elevation of the lower strata which are here exposed, the conglomerate and its superincumbent coal measures being brought within the influence of denuding currents, have been swept entirely away, leaving no space between to show the original continuity of the deposites of the now insulated basins. Commencing with our eastern or middle district we find seven distinct synclinal basins of the coal measures grouped in close connexion. These may be compared to a like number of long and narrow troughs, lying in contact and parallel with each other. Their range is south sixty-five degrees or seventy degrees east, though particular portions affected by faults or by greater disturbances, present considerable deviations from that direction. These are either separated from each other in every case, by parallel anticlinal ridges of conglomerate rock, or when that has been carried away, from a deeper denudation than usual, they are then divided by narrow valleys of the red shale of our eleventh formation. This latter, is the common structure at the eastern and western extremities of the coal fields, where we find the coal basins terminating abruptly in a prow-shaped form, in those conspicuous mountain spurs or high promontories which stretch eastward and westward from the elevated level of the coal field, into the lower red shale valleys of the Lehigh and Cattawissa. Between the two great axes of the Nesquehoning mountain and the Wapwallopen hills, in both of which the sandstones of our formation IX are brought into view, six lesser anticlinal axes or undulations of the dip are discoverable. The most northerly of these lines of elevation in the strata, crosses the river Lehigh, in the neighborhood of Whitehaven, and passing about west, ten degrees south, terminates in the great bend of the Little mountain, near Cattawissa. Upon the north side of this axis which passes through the central table land which unites the Green mountain with the Buck's ridge, we find the north dipping conglomerates of a small coal basin occupying the summit of Green or Hell Kitchen mountain. In the range of the above basin, but separated by an interval of six or seven miles, we have the Sugarloaf mountain, lying upon the north dipping beds of this same axis, but containing no coal measures. This latter eminence consists of a mass of the red shale rocks in a nearly level position, capped with a narrow plateau of conglomerate rock, about one hundred feet in thickness. Continuing our range still further westward, we find the small coal fields of M'Cauley's mountain, crowning an isolate ridge of conglomerate, which has been at one time evidently continuous with the conglomerate stratum of the Sugarloaf and of the Green mountain. On the south dips of the above mentioned axis lies the conglomerate of Buck's mountain. Again, at the junction of the two branches of Black creek, we find evidence of another additional elevation which may be traced eastward through the long summit of Black creek ridge until it is lost in the neighborhood of the Lehigh, and westward through the Racoon valley, between the south Buck's mountain and the Little Sugarloaf as far as the base of Little mountain. Between these two axes lies the coal basin of Buck's mountain. Our third axis is that of the Council ridge, situated south of the last line, about one and a half miles. This, in its turn, seems to disappear eastward in the vale of Sandy creek, and westward in the red shale valley at the foot of Little mountain. Between this and the former, lies the coal basin of Black creek, a long narrow trough of conglomerate, with a rather shallow deposite of coal measures, commencing at the head waters of Black creek, and terminating in the Little Sugarloaf mountain, which lies between the two branches of the Tomhickon creek.

The fourth in order, and ranging at a like distance south from the last three, is an axis observable near the junction of Hazle creek and Dreck creek, which we shall call the Dreck creek axis. This is continued eastward through the centre of Pissmire ridge to the Lehigh, where it terminates. We may trace its prolongation westward to the very extremity of Green mountain, and thence through the Cattawissa valley, in which it seems to expire. Between the Council ridge axis and that last described, we find the valuable basin of the Hazleton valley extending eastward to the extremity of Pissmire hill, and westward to the end of the Green mountain.

Our fifth axis is the great one in the southern ridge of Pissmire hill, passing near the town of Beaver Meadow. This line of disturbance traverses the valley of Red Shale, called the Indian survey between Spring mountain and the north-eastern prong or spur of Pissmire ridge, while westward, after leaving the coal field, it keeps along the south foot of Green mountain, until lost in the Catawissa valley. This axes is the southern limit of the Dreck creek basin, a coal deposite, which in depth and breadth is much inferior to that of Hazleton, to which it is precisely similar in the topography towards its east and west prolongations. In the red shale valley of Quakake creek, we find another axis which flattens out and disappears near the crossing of the Beaver Meadow rail road, through this valley. It is this disturbance which causes the northern dip of the conglomerate in the Spring mountain. Upon this stratum, and upon the southern dipping conglomerate of the Pissmire ridge, lie the coal measures of the Beaver Meadow basin. This is perhaps the largest and most valuable coal field in the *group*, but is at the same time the most disturbed by *dislocations* and *rolls* of the strata. Commencing at the town of Beaver Meadow, and proceeding westward, we may trace the rise and declension of several axes or wrinkles, caused as it were by the upheaving and by the consequent inward pressure of the two bounding masses of the conglomerate. Such is an outline of the general structure of the eastern middle group.

Our western middle group of basins, including the coal fields of Mahanoy and Shamokin, presents some features of a different character. Owing to their position between the eastern terminations of the two great axes or lines of elevation, those of the Roaring creek and Mahantango valleys, we find the anticlinal disturbances in this group of considerable size and consequence, dividing the extremities of the coal basins and thus causing them to branch off into several small spurs of a synclinal structure, which, however, communicate uninterruptedly with the main valleys or coal basins.

Commencing at the western termination of the great Shamokin coal field where the north and south dipping ranges of the conglomerate unite together, in a high knob between eight and nine miles west of Shamokin gap, we can trace as we go east, a regular basin of coal measures of uncommon width and depth, disturbed only by a single central axis of elevation, which does not bring the lower rocks to the surface. This axis will be found to assume its maximum elevation and importance, uptilting the strata near the Shamokin coal mines, when it soon begins to fall away towards its eastern prolongation, disappearing after a distance of five or six miles. Two or three other similar disturbances, but of less note, begin near Shamokin gap and proceed eastward in a parallel direction, but die away in short distances and are succeeded by others of the same nature. About the crossing of the Sunbury turnpike the valley presents an appearance of remarkable regularity in its topography, if we confine our views to its western portion, but looking towards the east we perceive the rising of two prominent ridges of nearly equal elevation with those enclosing the whole coal field, and which prove upon examination, to contain the terminations of two great anticlinal axes or lines of elevation dividing the coal field into three branches. The northern and middle of these subordinate basins terminate abruptly in short and high hills. The southern, however, continues with a longer reach along the southern side of the north ridge of the Mahanoy, and thence after being completely divided by a breach or gap runs out in the Head mountain, which is a dividing ridge of the Quakake valley, lying almost in immediate contact with the Spring mountain. In the proximity of these two latter mountains and their anticlinal axes, we behold the natural link connecting our eastern and western sets of coal basins. Parallel with this last axis and in the same long spur of the Mahanoy mountain, there is another diminutive trough of the coal measures, which is, in like manner, an extended arm of the great coal basin of the Mahanoy. The central axis of Head mountain, dividing these two lesser basins, is a low ridge of conglomerate rocks, which, if traced westward will be found to be identical with the great anticlinal axis of Locust ridge which separates the two main basins of Shamokin and Mahanoy. The great basin of the Mahanoy valley terminates westward in a knob of the main mountain, forming the south boundary of the Mahanoy basin, at a point about two miles south of the Shamokin mines. This knob faces westward upon the Red Shale valley, which lies between the north Mahantango ridge or Line mountain and the south boundary mountain of the Shamokin basin.

From this point eastward, the valley gradually increases in breadth and depth as far as the western commencement of Bear ridge, when it reaches its greatest expansion. The great anticlinal axis of the Bear ridge, rising in the centre of this coal basin, divides it into two large branches. The northern one of these, or the basin of the Shenandoah valley, if traced eastward, will be found identical with the southern coal trough of Head mountain above described. The other lying to the south of Bear ridge, after continuing eastward about five miles is there subdivided by another similar axis but of less elevation. The two troughs thus formed contracting and rising, extend eastwardly into two long spurs or fingers, the more northerly of which terminating in a high knob facing the south branch of the Quakake valley, feeds the sources of the Mahanoy creek. The southern of these synclinal troughs on the other hand, heads eastward in a knob called the Hossasock mountain, reaching out from Mahanoy mountain into the Locust valley. A third, but smaller basin also takes its rise in this knob of the Mahanoy mountain, and terminates near the summit of the steep plane on the Danville and Pottsville rail road. South again of this last shallow trough, is another, taking its rise in a knob of Broad mountain, which faces the Nesquehoning valley towards the east, being a coal basin of little depth or consequence at its origin, but which may readily be traced and will be found to be identical with the central basin of the Broad mountain. The basin which we mentioned as terminating at the head of the steep Mahanoy plane, would, if continued, pass into a narrow coal trough lying along the northern edge of Broad mountain, and ending in a shoulder or knob on its western escapement opposite the junction of the Great and Little Mahanoy creeks. The central basin of Broad mountain, (in which is Spohn's tavern on the turnpike,) terminates westwardly in a spur jutting forward from Broad mountain towards Lykens' valley. This spur contains also the heading of a second very shallow and less obvious basin lying immediately to the south of the former, but which is of small consequence, as it seems to contain not even a remnant of the coal measures. This, and a third still narrower one may be seen at the passage of the Centre turnpike over Broad mountain. It is doubtful if either of these three last mentioned mountain troughs contains any considerable quantity of coal measures. Beside the spur of Broad mountain which we have just mentioned as jutting westward, two others are conspicuous in the same neighborhood facing upon the Lykens' valley. These two prominences of the plateau of Broad mountain, (the most southerly of which is the longest, extending itself several miles towards the west,) contain *two branches of the Mine hill coal basin.* The central valley of red shale dividing these two knobs, contains an anticlinal axis which may be seen terminating in the Mine hill valley, about a mile west of Coal Castle. The axis next south of this, which may also be traced for a great distance along the valley of Pine creek, and upon which this creek has its source, is *the true axis of the Mine hill*, dividing the Pottsville from the Mine hill basin. This in its turn, terminates in the neighborhood of Tuscarora, where this basin of Mine hill coalesces with the great southern one, or that of Pottsville and Mauch Chunk. Such is a general outline of the districts which have been embraced by our researches and surveyed in considerable detail during the past season.

The great southern coal valley of Pottsville, has also been in many of its parts minutely explored. In the course of this investigation, the situation of numerous important points was referred to a map; all disturbances of the strata that came under notice, were traced as far as possible or to their terminations, and their extent and direction ascertained, with a view to the discovery of the *general laws*, regulating the disturbances of the strata in this intricate but valuable region.

Particular observations have been made, with a view to form an opinion as to the capacity of the Bear ridge district, as a productive coal field. The present position of the Bear ridge tunnel, seems to adapt it very perfectly for an opening and outlet to the main body of the coal field north of it. The Bear ridge, is, as we have already indicated an anticlinal axes, coming in from the Quakake or Locust valley and dying out in the centre of the coal basin near Girardville. This axis, from its origin at Girardville, increases in elevation eastward, bringing up first the lower coal measures, to the surface, with their coal beds as at the tunnel, and afterwards in succession, all the conglomerates and other rocks to the underlying red shale which appear first near Brouse's tavern, on the Catawissa road. At the tunnel we have two or three coal beds rising from the vale of Mahanoy creek at an angle of from sixty to fifty degrees, which after saddling the ridge, dip rapidly downward to the north at an angle, increasing from ten to thirty degrees as we follow them more deeply. But in addition to those beds which pass over the ridge without fairly cropping out upon the surface, we have upon the northern side and superimposed upon them six or seven others, many of which must be of considerable thickness. The vale of Shenandoah, into which these north dipping coal beds descend, is a long narrow valley about one-third of a mile in breadth, reaching eastward to the sources of Shenandoah creek, and westward to a little beyond Girardville. The dip of the coal measures upon its northern side which is formed by the south flank of Locust ridge, is south. This, with the northern dip of the strata of the Bear ridge forms a regular synclinal trough whose eastern prolongation terminates only in the end of the Head mountain, of whose southern basin it is the true continuation. The denudation in this basin opposite Bear ridge has been comparatively small, a great depth of coal measures still remaining on both sides of the valley. So far as we may judge from external indications, these are remarkably regular and free from anticlinal or other disturbances. Considering these circumstances, we may readily conceive, that great advantages would follow the completion of the present partially finished tunnel through the Bear ridge. Not only would all the coal beds of the south and north sides of Bear ridge be made accessible to the miner, with an uninterrupted range to the eastward for many miles, but the tunnel being driven at a level of only sixty feet above the level of Shenandoah creek, might form on outlet for all coal mines east of that point on either side of the basin.

A set of Geological specimens has been collected illustrating all the beds of the conglomerate, and the coal measures of the Bear ridge and Mahanoy mountain. A large collection of fossil impressions of the coal plants has also been gathered from the rocks of the tunnel.

In the great southern basin, the operations of the survey during the latter part of the season have been directed to the elucidation of a subject of the greatest interest to the miner and the land owner in this region; I mean the disturbances of the coal beds and their included strata. To this end, the dip, thickness and peculiarities of stratification of the coal beds have been obtained at the principal openings, their distances measured, their positions, as far as practicable, traced upon a map of an adequately large scale, and attempts made wherever any hope of success appeared, to identify the beds at distant openings. All the anticlinal disturbances which time permitted us to trace, have also been carefully noted, and a number of remarkable faults observed, with a view to ascertain, if possible, some rule respecting their directions and influence upon the strata. From the large number of specimens taken during the last season from this district, it was deemed unnecessary to collect many of these in the southern basin, excepting in a few instances.

A few of the conclusions arrived at, will serve to explain the nature and results of these investigations.

From the comparison of a great multitude of facts we are led to conclude that the southern coal basin throughout its whole length, is traversed longitudinally by several great *lines of disturbance*, in the range of which may be found a greater number of faults, downthrows, and longitudinal displacements of the strata and the coal beds, than can be discovered in the belts intervening between them. These lines of disturbance are indicated either by regular anticlinal elevations, which commence and terminate in distances varying in length from a few hundred feet to several miles, or by simple but sudden changes of the dip, (the rocks not forming a complete axis) or by crushed coal seams where no disturbance in the adjoining rock is visible. Of the first kind of irregularity, the Bear ridge east of Port Carbon and the axis of Peach mountain are well known instances; the second kind may be observed in the rather sudden change of inclination at the foot of Mine hill, from steep south dips of sixty, to gentler ones of ten or even five degrees south. For the latter, we may refer for illustration to the beds of the barren tract and the faulty portions of the Gate vein. Passing over the eastern portion of the basin through which, indeed, anticlinal disturbances are well known to pass, let us commence with the Sharp mountain at Middleport, near Pottsville.

From this eastward to a point south of the above mentioned village, the rocks of Sharp mountain being overtilted or inverted towards the north, have a steep southern dip; at this point, however, we find them changing to a perpendicular position, and from this rapidly to a north dip, then to a west, and again to a south one, the last being gentle and not exceeding thirty degrees. In these changes, the southern or outward base of the mountain sweeps sharply round in the form of a bold promontory, and the returning or northern side of the spur contains the last mentioned southern dips.

Again repeated, but with less steep inclinations of the strata, we have the same series of changes, after which deviations, the mountain assumes a course of forty-four degrees east of north for some miles, and then continues in its ordinary range. It is easy to conceive, without entering into theoretical considerations, that these disturbances have been caused by the intrusion of two anticlinal axes which have their origin in the Red Shale valley, between the Second and Sharp mountain. These seem soon to flatten out and disappear within a short distance to the west in the coal basin, but in the several anticlinal elevations and the numerous faults of the Bear ridge, we have evidence of a disrupting effect prolonged much further in that direction. We loose sight of this line of disturbance near Port Carbon.

Passing towards the western extremity of the basin, we perceive two great anticlinal axes entering it from the west from Williams's valley, the southern and lesser of which is probably prolonged eastward, through the range of the barren tract, noted for the crushed character of its veins of coal, while the other, a far more important axis, passes along the central part of the basin, producing, as far as evidence goes, the Minersville disturbances, (which may be seen in certain coal beds worked by Spencer & Co.) and in others, less known, some miles west of these, and prolonging itself further eastward into the great Peach mountain axis itself.

Our next conspicuous range of disturbance in the coal measures, lies along the foot of the Mine hill, but is of a less striking nature than the former. By its influence, the flat beds of the Mine hill seem to have been brought to their present posture. The crushes and rolls in Neighley's, and some other of the Mine hill workings, present other examples of this line of dislocation.

From the above and other analogous details, we conclude that the number of coal beds at present worked in this district has been somewhat over rated, for, in no instance can a north dipping bed be found, to which there are not two related south dipping portions. Thus the Lewis and Spohn veins opened upon the workings of the North America company's lands, must be considered as identical, having a north dipping or perpendicular bed, and none other between them. In consequence of this fact, all attempts to trace the Lewis and Spohn veins as separate beds, either eastward or westward beyond where they are already known, will probably prove abortive. One vein alone can be hoped for, unless the dislocation is prolonged to a greater distance than present evidence indicates.

SECTION 3.

A general sketch of the operations of the survey in the third or south-western Appalachian district.

In conducting the examination of the third district of the State, or that which is occupied by the half of the Appalachian chain, included between the Susquehanna river and the southern boundary of the State, the exploration was begun at the north-eastern extremity of the region in Union and Lycoming counties, and pursued regularly towards the south-west, following the course of the formations. The season was commenced with the survey of that portion of Union county, known as Buffalo valley, and as it was deemed judicious to confine our attention for the season, to a tract of moderate breadth, the lower part of Union county, situated to the south of New Berlin and Jack's mountain, was reserved for an ensuing year.

The strata underlying the broad surface of Buffalo valley, belong, with the exception of one or two small patches of formation No. VIII, near Lewisburg, to formations V and VI, the general composition and prevailing mineral contents of which will be found described in the last annual report.

As formation V of our series, is the depository of the valuable and interesting *fossiliferous iron ore* found in such considerable abundance in the eastern half of Montour's ridge, in Columbia county, it was deemed of consequence to the interests of Union county, to examine the red and variegated shales and sandstones of which this formation consists, with all the minuteness compatible with the rather obscure developements of the strata in most parts of Buffalo valley. A remarkably near approach to identity being discoverable between the several members of this great fifth formation as seen in Buffalo valley and in Montour's ridge, it was not difficult to recognize, from the examinations and measurements undertaken the previous year in the latter neighborhood, the precise layers which should contain the fossiliferous iron ore, supposing it to exist at all in Buffalo valley. This valley encompassed on the north and west by the terminating spurs of the broad belt of mountain ridges that crosses Centre and Mifflin counties from the south west, the lines of elevation of these hills prolonged beyond their extremities, are traceable as far as the Susquehanna river, uptilting the strata in Buffalo valley, in such a manner that their beds are arranged in at least six nearly regular and parallel troughs.

In the upheaving of the strata along these several adjacent lines, the soft rocks of formation V, as well as the equally destructible layers of the limestone which overlies it, have been subjected to a very wide spread action of the floods, which at one time evidently swept down from the neighboring mountains. The consequence has been, that the uppermost of these rocks, the limestone formation VI, remains in but two narrow belts in Buffalo valley, composing in the one instance the limestone ridge south of Youngmanstown, and in the other, Dale's hill, directly west of Lewisburg. In each case, the preservation of the limestone stratum has been the result of the trough-like position of its beds, which has defended them from the currents that have carried away the more exposed portions of the rocks lying nearer the lines or axes of elevation. Where the trough or synclinal axis of Dale's hill crosses the Susquehanna, a narrow belt of formation VIII has, from this circumstance, been also preserved, the dark slate characteristic of the bottom layers of that formation, having been left about one mile north of the town of Lewisburg.

This undulating position of the rocks in Buffalo valley, accounts for the great width over which a single stratum, namely, formation V, is there spread out. By repeatedly bringing to the surface the same portions of the deposite, this feature greatly facilitates the search for any imbedded mineral layers, such as the fossiliferous iron ore of this formation.

But notwithstanding a long continued and minute examination of the rocks thus extensively exposed, the fossiliferous iron ore has only in a few places been satisfactorily developed, while in no instance does it exist as a stratum of sufficient thickness to render it an object of much interest to the manufacturer of iron. No uncertainty can prevail respecting its position in the formation, which agrees entirely with that occupied by the thicker band of ore of Montour's ridge, now extensively worked. In one instance, in which we have met with this ore, namely, on the farm of Messrs. Dersham and Rank, about three or four miles from New Columbia, the apparent thickness of the ore was about seven inches, which is not sufficient to induce any attempt at mining it. It was found in another case in the same relative position, to the beds of the red shale and sandstone formation, on the land of Aaron Chamberlain, but though the fragments of the ore are numerous on the surface of his fields, no layer of the mineral having much thickness has been discovered. Nearly one mile south of Lewisburg, along the river side, several thin seams from four to six inches in thickness have been found. They are very fossiliferous, being of the hard calcareous variety and would not justify the expense of mining them. The ore also occurs near Miller's saw mill, on Penn's creek, on the property of Robert Shippen; but as no excavation has yet been undertaken, its thickness remains unknown. Near this place there occurs a ferruginous bed of rather peculiar aspect. It consists of small particles of quartz, firmly cemented together by oxide of iron, and is between two and three feet in thickness.

Besides the fossiliferous ore now mentioned, which is peculiar to formation V, we have met with an entirely different variety in several places in the western part of Buffalo valley, occurring in the same formation, but to all appearance connected with the shales which occupy a rather higher position in the stratum, than the calcareous fossiliferous beds associated with the fossiliferous ore. This variety is a brown argillaceous ore, of a shelly and coarse honeycomb structure, its cavities being usually occupied by an unctious yellow clay, the predominant material of the soil in which it rests. An ore very similar in structure and composition occurs in our formation VIII. in Perry county, and a variety somewhat analogous, is to be met with quite frequently in the slates or shales of the bituminous coal measures of the western and northern counties, where the kidney ore has acquired nearly the same aspect at the outcrop of the strata, by the decomposing agency of the atmosphere. A mine of the kind of ore above spoken of, occurs about one mile south of Miller's saw mill, and has been somewhat extensively worked. Another deposite of the ore similar to the last in character and in its geological relations, occurs about six miles west of Millers'.

After the detailed examination of Buffalo valley, a few only of the results of which are here presented, was concluded, our explorations were extended to the mountains which skirt it on the west, afterwards to White Deer Hole valley, and subsequently to all that part of Lycoming county lying south of the base of the Allegheny mountain.

Moving forward in a south-west direction, we next entered Centre county, which was examined from the base of the Seven mountains to the base of the Allegheny, as far westward as the end of Nittany mountain. There remain, however, a few small neighborhoods in the district here specified, the true Geological structure of which was not fully ascertained for want of time. Some of these will be mentioned in this chapter. With these exceptions, the region designated has been, it is believed, adequately explored, its curious and highly intricate Geological structure unravelled, and some important advances made towards the laws which influence the distribution of its mineral resources.

I shall now describe as succinctly as possible, the Geological features of the region explored, in order to convey more definitely some idea of the situation and extent of the several formations which it includes. A true knowledge of these features is indispensable to the successful tracing of any useful mineral deposites.

FORMATIONS INCLUDED IN THE DISTRICT EXPLORED.

Confining our present descriptions to the country south of the base of the Allegheny mountain, the formations of the portion of the district explored are, first, the great blue limestone of the valleys of Centre county, or formation II; secondly, the slate, which in all cases skirts the margins of these valleys, or formation III; thirdly, the sandstones, or formation IV, which compose the Bald Eagle mountain and all the other high ridges south of it; fourthly, the red and variegated shales and sandstones, or formation V, which have already been referred to as composing the chief part of Buffalo valley, and which occur also in White Deer Hole valley, and range along the northern base of the Bald Eagle mountain throughout the whole of its course; fifthly, the blue fossiliferous limestone, or formation VI; sixthly, the fossiliferous sandstone, or formation VII, a thin stratum in this region and sometimes entirely wanting; and lastly, formation VIII, all of which three latter rocks are confined to the valleys above spoken of, as containing formation V.

In the section of the country to which reference is now made, formations II and III are confined to the fertile agricultural valleys of Centre and Lycoming counties, which lie to the south-east of the Bald Eagle mountain. These valleys are, Nittany valley, Sugar valley, Little Sugar valley, Brush valley, Penn's valley and Nippenose valley. In these beautiful and deep valleys between the mountains, formation II occupies nearly the entire surface. Formation III, being a stratum of far less thickness, and usually dipping away from the limestone under the base of the adjoining ridges, is restricted to a narrow zone, begirting each limestone valley with a margin of slate. The several beds of formation IV, constitute all the higher mountain ridges of the district, viz: the Bald Eagle mountain, the several branches of Nittany mountain; also White Deer mountain, Brush mountain, Short mountain and the long complicated range called the Seven mountains. Formation V spreads largely over Buffalo valley, and it occupies a belt in White Deer Hole valley ranging in another narrow tract to the end of Bald Eagle mountain, around the extremity of which it doubles to the westward, following the base of this ridge throughout its whole course by the valley of the Susquehanna river and the Bald Eagle creek.

Formation VI has a more local range; it composes, as before said, the limestone ridge near Youngmanstown, and that called Dale's hill, both in Buffalo valley; and it is found in White Deer Hole valley, on both sides of the western termination of the Muncy hills; it occurs, besides, in an almost uninterrupted range near the middle of the valley included by the Bald Eagle and Allegheny mountains.

Formation VII, owing to its greatly reduced thickness in this part of the State, and to its very destructable nature, being a porous and loosely cemented sandstone, is more rarely to be seen, though it shows itself in places along the middle of the valley which lies northwest of the Bald Eagle mountain, in close connexion with the limestone just referred to.

Formation VIII, or the olive coloured slate and sandstone stratum, displays itself in a small patch in Union county, (consisting of only its lower beds,) in the neighborhood of Lewisburg. It also enters our present district forming the western portion of the Muncy hills, and occurs in a long and heavy belt two or three miles in width, skirting the southern or south-eastern base of the Allegheny mountain, throughout its entire range, not only in Lycoming and Centre counties, but entirely across the State.

In order to have a correct conception of the Geology of the parts of Centre, Lycoming and Union counties, that have been examined, it is necessary to dwell, as briefly as possible, upon some of the leading features of the region. From the valley sometimes called the Lewistown valley, which runs through the centre of Union and Mifflin counties, to the base of the Allegheny mountain, to the north-west, the whole included broad belt of country, consists of a succession of nearly parallel mountain ridges, remarkable for the straightness of their course, the even outline of their summits, the general similarity of their form, and their uniform height above the intervening valleys. Between these ridges we have a series of long, narrow and nearly straight limestone valleys, the southernmost of which is Kishacoquillas valley, in Mifflin county, while on the north-west, are Nittany and Nippenose valleys, in a line with each other.

Now such is the necessary dependence of the Topographical features of any diversified region upon its Geological structure, or, in other words, so entirely have the present bold and singular outlines of this district, been impressed upon it, by the agency of causes strictly Geological, namely, by the upheaving of the strata along certain lines and the simultaneous destruction of large portions of them, by the scooping action of a mighty flood, that we shall be much assisted in any effort to comprehend the intricate Geography of this region, by devoting a moment's attention to the following Geological views.

Of the seven formations enumerated above, as comprising the rocks of the portion of the State before us: formations II and III, are respectively a limestone and a slate stratum, which are at all times more destructable than sandstone; but especially so, must they have been in their soft or pulpy state, at the time of their elevation from the bed of the ocean, in which they were deposited.—Hence they have been more deeply excavated than the harder ponderous beds of sandstone of which formation IV consists. We accordingly find formations II and III, always in the deep and nearly level valleys, and formation IV, in the high and steep mountain ridges. Of the other rocks, formation V consists chiefly of soft slates and calcareous shales. Formation VI, of limestone, which, like formation II, was evidently of a very soft consistence, when first uplifted, and formation VIII, of a mass of slate and argillaceous rocks. These would all be liable to very extensive destruction, whenever subterranean uplifting forces would bring them within the reach of those tremendous currents, which those same uplifting actions set in motion.

It comports entirely with these views, that we find these destructible rocks restricted to the valleys or broad plains between the sandstone mountains. In the district before us, we see them confined to the Buffalo Valley, White Deer Hole Valley, and the valley at the base of the Allegheny mountain. Unless where formation VII, a sandstone stratum, dwindles to quite insignificant dimensions, it composes a steep and sharp ridge, though from its small thickness, this is always of unimportant height, when compared with the mountains that contain its more massive prototype, formation IV. These facts and others of a like character, are all important in their applications; affording us often the best clue in an unexplored or intricate district in tracing the distribution of any bands or deposites of mineral matter, which we may be in search of. Thus in traversing any portion of the district between the Susquehanna river and the Maryland State line, in quest of the valuable fossiliferous iron ore, peculiar to certain layers of formation V, it is of extreme advantage to trace the stratum by aid of the topographical features which belong to it, and to its contiguous formations, and it is only by understanding the connection between these features and the agents concerned in producing them, that we can with any success detect the stratum we are searching for, if any irregularity has thrown it out of its more ordinary position. The evidence of this will be manifest, in relation to the band of ore alluded to, when we come to another part of this report.

Bearing carefully in mind, therefore, the difference in the destructibility of the several rocks, while under the action of the currents, which have rushed across them with such tremendous violence, sweeping off all their more exposed portions, let us advert to the operation of those subterranean upheaving forces which seem to have acted on the strata with such resistless energy, uplifting, inclining and dislocating them in certain lines, which we now proceed to trace. By these two causes we shall account for all the features in the Geology and Topography of this intricate region. I shall, therefore, describe as concisely as possible the *lines of elevation* of the strata, or technically, the *anticlinal lines*, and at the same time the lines of *greatest depression* or *synclinal lines*, which range through the valleys and ridges of the district, and shall offer also a brief description of the Geology and mineral contents of the belts of strata, which they disturb.

NITTANY VALLEY AND ITS ANTICLINAL AXIS.

This valley, properly speaking, commences at the south-western extremity of Nittany mountain, where the broad Half Moon valley is divided by the mountain into this, its wider branch on the north, and Penn's valley on the south. It is bounded on the south-east, by the Nittany mountain, and on the north-west, by the Bald Eagle mountain. Where Nittany valley opens into the Half Moon valley, it is about six miles wide, but as we advance north-eastward its width contracts to between four and a half and five miles opposite Bellefonte, and three and a half or four miles opposite Howard's gap, nine miles from Bellefonte, and to about two and a half miles opposite Millhall. Further east, the two converging boundaries of the valley unite, closing it up at a point nearly south of Dunnstown.

There is a central tract running through Nittany valley, between two and three miles in width, which is denominated the *Barrens*. It has a sandy and stony soil, is singularly destitute of water and remains therefore in its native uncultivated condition. It is here, that nearly all the large deposites of valuable brown argillaceous iron ore, which have rendered Nittany valley and its neighborhoods celebrated for their iron manufacture, are found. The surface of these barrens is considerably elevated, rising above the general plain of the valley into a ridge, which begins about two miles from Bellefonte, and extends eastward about twelve miles, where it subsides. From its termination, eastward to the head of the valley, cultivation extends entirely across from mountain to mountain. The features of this valley, indicate many departures from that more perfect regularity of geological structure, which prevails in several of the other valleys of anticlinal form, which lie parallel with it, towards the south east. The present report does not permit me, however, to discuss these local disturbances of stratification.

Though numerous irregularities in the dip of the strata prevail in some parts of the valley, they are inconsiderable, when compared with that general uniformity in the inclination of the beds, visible throughout its entire length. One great anticlinal axis runs through this valley from one extremity to the other. It is rather a portion of a still more prolonged axis of elevation, which is traceable from the neighborhood of Hollidaysburg, through the end of the Brush mountain, and thence along the Sinking Spring, Half Moon and

Nittany valleys, and still further through the middle of Nippenose and Musquito valleys and out through the end of the Bald Eagle mountain into the plain east of the Susquehanna, as far as Muncy creek. The position of this line from which the strata are tilted away in opposite directions, is not central through Nittany valley, except from the head of the valley to the neighborhood of Millhall. From this point south-westward, it is nearest the Bald Eagle mountain. All the strata which lie to the north-west of it, viz: the limestone beds of that side of the valley, the slate of formation III, which rests upon these and passes under the base of the Bald Eagle mountain, the sandstones of formation IV, of the same mountain, the rocks of the formations V, VI, VII and VIII, which occupy the valley between the Bald Eagle and the Allegheny mountain, all decline towards the north-west, with a greater or less steepness, the degree of inclination generally abating as we recede from the anticlinal axis to the slightly inclined rocks of the Allegheny. On the other hand, the rising of the strata along this axis has caused all those situated to the south-east of it as far as the summit of the Nittany mountain, that is to say, the limestone beds of the south-eastern half of the valley, the slate at the foot of the mountain, and the sandstone rocks of the mountain itself, to dip towards the south-east. The sandstone stratum, formation IV, dipping on the north-west side of the mountain, towards the south-east becomes horizontal along its centre, and displays on its south-eastern side, an inclination in the opposite direction, or towards the north-west, so that the rocks of the mountain lie in a trough form, technically denominated a synclinal axis. Such is the structure of this mountain opposite Bellefonte, and throughout several miles of its length, towards its western extremity; but further to the north-east it becomes somewhat complicated, both in regard to the dip of its strata and its topography. Further eastward, in place of a synclinal axis or trough in the rocks, there is an anticlinal axis, the same which brings up the limestone in Big and Little Sugar valleys, which divides the mountain into two branches. As we advance still more towards the north-east, each of these branches of the mountain in its turn, becomes subdivided by other similar short axes of elevation. In consequence of these numerous parallel upliftings of the strata of this mountain, there are many alternations of dip in the rocks, from south-east to north-west, and hence the topography of the chain being intimately dependent upon these circumstances, has acquired a highly complicated character.

Of the rocks of Nittany valley I have already stated, that the great blue limestone stratum of our state, formation II, occupies almost the entire surface of this valley, even capping in most places the sandy ridge, called the barrens. The character and quality of the rock, however, varies greatly in different belts. Beginning with the lowest beds visible, or those which have been brought to the surface by the movement of elevation acting along the anticlinal axis, we find immediately adjacent to this line, lying along the central ridge or barrens, many masses of sandstone, evidently derived from the underlying beds of formation I, but in no instance have we yet found that rock in place. In other parts of this central ridge, the limestone, formation II, shows itself, possessing in some degree the sandy composition of the inferior rock. Receding a little towards either side of the valley, or in other words, ascending into rather higher portions of the stratum, we meet a moderately thick body of tolerably pure limestone, which contains, however, some layers of sandstone. Above this, there occurs a pale blue rock in numerous beds, having a very close resemblance to limestone, but singularly enough, containing little or no calcareous matter, being in fact, a very pure and fine grained siliceous rock, a species of compact chert, both in its texture and composition. The next belt in the ascending order, comprises a large body of very excellent limestone, most generally of a very pale bluish aspect. In this, there frequently occur seams of white calcareous spar. Higher still in the formation, or, indeed, in its uppermost subdivision, some of the beds are more or less bituminous, which they indicate by their fœted smell, some are decidedly argillaceous, manifesting a close approach to the immediately overlying slates of formation III, and others are characterised by a profusion of fossil shells and other marine remains. These are the fossiliferous bands of formation II, at least in this region of the State.

The upper layers approaching to the slaty rocks of the next overlying formation, III, contain a large amount of argillaceous matter. A little higher in the stratum, these beds alternate with numerous dark blue or almost black bands of calcareous slate, having a remote analogy in their appearance to those slates which lie in contact with seams of coal and consequently many abortive attempts have been made to discover coal in these rocks, not only in Nittany valley, but in the other limestone valleys which occur to the south-east and even in many places in the great Kittatinny valley where these rocks are largely developed.

The soil derived from these dark calcareous slates which occur among the alternating bands interposed between the main masses of formation II and formation III, is deservedly esteemed to be among the most fertile in the State, being admirably adapted to the cultivation of wheat. This is well exemplified in the productiveness of some of the farms in the eastern part of Penn's valley, where the soil of a considerable tract of country has been derived from the source mentioned. The cause of its productiveness is obvious; while that from the slate is comparatively unproductive, owing to the excess of clay which it gets from that rock and to its almost total destitution of lime, and on the other hand, while that which rests upon the limestone, though of better composition and texture is scarcely more impregnated with calcareous matter, in consequence, probably, of the facility with which the lime has been removed by the percolation of water through its open materials, the soil of these intermediate strata which have a sufficiency of lime in their composition, would appear to be perpetually replenished with this valuable ingredient from the facility with which the soft rock moulders down after ploughing and crumbles into mellow earth by the action of the atmosphere.

Formation III, which is a mass of fissile slate of various colors from light yellow and grey to dark blue and dingy olive, exists as a stratum of several hundred feet thickness, ranging in a belt along both the south-eastern and north-western margins of the Nittany valley, and extending commonly up the flank of each of the bounding mountains from a little outside of the base to within about one third of the total height from the summit. The lower layers, contiguous to the underlying limestone, are those which are most apt to be calcareous and to contain fossils, though these distinctive features belong also to some of the higher beds. In Nippenose valley some parts of this rock are highly fossiliferous, and the same remark will apply to the upper beds of the underlying limestone seen in that singular valley.

The strata of Nittany valley have been dislocated to an extent not witnessed in the anticlinal valleys which lie more to the south-east. But the disturbances prevail almost wholly along the north-western side of the valley, especially close to the foot of the Bald Eagle mountain. The irregularities in the dip of the rocks are traceable from Millhall, to nine or ten miles south-west of Bellefonte, and by observations made during a former season, I am led to think that they continue the whole way to the Little Juniata. The inclination of the strata to the south-east of the main central anticlinal axis is never steep, rarely exceeding thirty degrees.

Though a great number of excavations for iron ore were visited in Nittany valley, many of which are highly interesting from the richness of the ore, and the prodigality in which the mineral is supplied, and from the curious features, seen sometimes in the deposites in their connexion with the underlying limestone strata, yet no satisfactory explanation has been arrived at concerning the origin of the ore, nor any general practical rule discovered, calculated to conduct us with a desirable degree of certainty, in our search after large deposites of the mineral. Some light has, however, been gained from other quarters of the State, through observations made upon the same formation. If these should be corroborated by future researches, some part of the obscurity which rests upon this difficult, but important subject, may perhaps be removed. For the present, I deem it premature, until the chemical examinations connected with the survey shall have been more advanced, to enter into the complicated enquiries arising out of the scientific investigation of our ores of iron.

FORMATION IV, AS IT OCCURS IN BALD EAGLE AND NITTANY MOUNTAINS.

The Bald Eagle mountain, the boundary on the north-west of the three valleys of elevation, Nittany, Nippenose and Musquito valleys, consists of the sandstone rocks which constitute formation IV, uptilted towards the north-west, generally at a high inclination from the anticlinal axis, which traverses those three valleys in a longitudinal direction. From its eastern termination at the Susquehanna, near Muncy, the outline of its summit is remarkably level and regular, until we reach the eastern end of Nittany valley, where the profile of the ridge becomes rather more undulating, its line of direction less straight, and its height somewhat diminished, all natural results of the disturbances near its south-eastern base in Nittany valley. Between Musquito valley and the ending of the mountain at the river, it is a single ridge with a finely rounded summit and contains the anticlinal axis running centrally through it. But westward from that point its strata dip in but one direction, or towards the north-west, and it exhibits throughout its whole length, two distinct parallel ridges with a considerable depression between them. These two summits are usually not more than a fourth of a mile apart, and possess about the same elevation, though not unfrequently the northern ridge rises above the other, attaining a height nearly as great as that of any of the other mountains in the region.

By adverting to the nature of the rocks composing formation IV, we find a ready explanation of all the features of Bald Eagle mountain, applicable, not to this ridge alone, but to all the high ranges in the district which consist of this stratum. The formation embraces three distinct sets of beds; the uppermost and lowermost being massive sandstones, while the middle member is composed of soft argillaceous red sandstones and red slates. The lowest of these divisions is generally a grey sandstone, sometimes greyish or white and occasionally bluish, and in some ridges includes beds which are green in color and very tough. All these varieties are very hard, though the weathered fragments do not show such sharp edges as those belonging to the upper division of this formation. Among these grey sandstones we find fossil remains of the Zoophytes, the class containing the corals, while in no instance have we met with these in the upper division. These lower strata of formation IV, compose the south-eastern ridge of Bald Eagle mountain, and extending our remarks to the other mountains, they belong in general to that ridge which is immediately adjacent to the limestone valley, or in other words to the anticlinal axis. The sandstone beds grow less compact as we approach the middle part of the formation, and acquire a more greenish hue and become speckled with brown oxide of iron. The central division of the mass consists, as already mentioned, of soft red argillaceous sandstones which are similarly speckled and interstratified with red slate. The upper member of the formation is a hard white and grey sandstone of even texture and often of extreme purity, easily distinguishable, if not recognized by its relative position to the other strata, by the frequent occurrence on its surface of a class of singular impressions formed by a marine vegetation called *fucoides*.

It is to the unequal destructibility of these three belts of rock, under the violent wearing action of a flood of waters which has rushed over their upraised edges, that we are to attribute the double ridge and the included valley on the top of the Bald Eagle mountain. The comparatively soft middle stratum, has been there scooped to a considerable depth below the more resisting sandstones which lie on either side of it.

In consequence of the triple character of formation IV, we invariably find the mountains that are composed of it, to consist of *two* ridges when the strata dip in the same direction, or when they contain no axis, either anticlinal or synclinal. But whenever an anticlinal axis upheaves these rocks, exposing the lower sandstone, then the mountain contains *three* ridges, the axis of elevation being in the middle of the central one. And when, on the other hand, a synclinal axis or trough-like dip of the strata extends through the middle of a mountain, consisting of formation IV, it then contains *four* separate ridges; the two outer ones caused by the sandstone of the lower division, the two inner ones by the upper sandstone member of the same formation. Guided by these facts, which are the necessary results of Geological causes, we trace in the perplexing intricacies of the geography of the mountain chain, which passes through the counties that lie between Maryland and the Susquehanna river, the most beautiful symmetry in the structure and connections of all the ridges. Were geographers, while mapping our mountain region, to make themselves familiar with the dependence of the configuration of the region upon its Geological structure, they would discover that the unerring rules of the science constitute their surest, or often their only clue, to those features of topography which it is their business to depict.—The confusion and distortion, so conspicuous in our present maps, would give place to features of curious and pleasing regularity, and to accuracy of delineation nowhere to be seen, while in the details, the benefits conferred by maps on the traveller, the engineer and the miner would be tenfold enhanced. By adhering to the views above presented, we have been enabled to reduce to order nearly every part of the seemingly complicated topography of the mountain ranges, which embrace the Bald Eagle, Nittany, White Deer, Brush and Seven mountains, and their subdivisions, and to trace the existence or absence of particular mineral beds suspected to occur in these wild regions. We have thus succeeded also in collecting some valuable materials designed to correct the present map of the State, or to contribute towards the construction of a better one.

Omitting a description of the curious Geological and Topographical structure of the Nittany mountain and its branches, which would require the assistance of maps and profile sections of the district, not suited to the plan of the present report, I shall proceed to mention in few terms, some of the other parts of the region, and to trace those axes of elevation which have imparted to each tract, its particular Geological structure and mineral resources.

The anticlinal axis of Nittany valley, prolonged as before mentioned, to the eastward, has elevated the limestone rocks composing formation II, to the surface in Nippenose valley, causing the strata to dip at a gentle angle each way from this line, which runs nearly along the centre of the valley. This valley is remarkable for its regular oval form, being an ellipse of about ten miles in length and four in its greatest breadth, and for the height and steepness of the rim of mountains which encompass it. The only avenue to it, without crossing a high zone of mountain land, is by a deep notch in the Bald Eagle mountain, nearly opposite Jersey Shore. The base of this notch is on a level with the surface of the valley, and hence through it, all the waters which enter the valley find their exit into the Susquehanna river. It is a remarkable feature about the drainage of the valley, that the numerous streams which descend into it from the surrounding mountains, all disappear through the funnel-shaped depressions called sink-holes, which abound over the surface of the limestone stratum of this valley, and what is not a little curious, the whole united body of these waters gushes forth to the surface again in a bold stream, passing through the mountain notch or gap, to which allusion has been made. A quarry of marble was opened and wrought with some spirit in this valley by Mr. Lawrence Wells. It is near John Bixler's tavern, three and a half miles from Rhodarmel's. The marble is a compact, dark, blue limestone, variegated by thin veins and specks of yellow crystalline carbonate of lime, or occasionally of white calcareous spar. The quarry has since been neglected. Layers, yielding similar marble, may be found near the centre of the valley east and west of this point.

Though minute attention was directed to the discovery of *iron ore* in this valley, the search has been to a great degree unavailing. Two circumstances discourage the hope of readily finding ore in any considerable quantity: first, the small depth beneath the surface at which we find the limestone rock; secondly, the absence of that bright yellow stain in the soil, which is so good an index of ore in Nittany valley. The soil here is generally dark brown or reddish.

The next limestone valley of the district is Sugar valley, formed by an anticlinal axis which has uplifted to the surface, the limestone rocks of formation II, between two of the branches of the Nittany mountain, a few miles east of the Bellefonte turnpike, and which passes along the centre of Sugar valley to its termination, and thence through the middle of White Deer mountain to its end, where the axis, leaving the ridge, passes out into the plain occupied by the higher formations of the series east of the river. In Sugar valley, the strata on the northern side of the axis have a steeper dip towards the north than those on its southern side have towards the south.

Our researches for ore in Sugar valley have not been completed, having been interrupted by the snows at the close of the season. A furnace for smelting iron was erected some years ago, about five miles to the east of Kleckner's tavern, but though the iron manufactured was pronounced to be of a superior quality, the supply of ore was insufficient to sustain the furnace. Of a number of excavations for ore which were visited, nearly every one seems to have been arrested at the depth of ten or twelve feet, by the underlying solid rock. This and other facts would appear to indicate a probability, that no extensive deposites of ore will be readily found in this valley, though further explorations are necessary to establish such an opinion. Sugar valley has an average breadth of nearly two miles, and is sixteen miles in length, the limestone which every where underlies it, being traceable to a point nearly seven miles east of Kleckner's. Between Sugar and Brush valleys, there are three distinct ridges, the middle and highest containing a synclinal axis in the upper member of formation IV. Towards the eastern end of Sugar valley, the topography of the mountain bounding it on the south, becomes more complicated.

The anticlinal axis, next south of that of Sugar valley, lies in a ridge called Nittany mountain, from the eastern end of which it is traceable to the Susquehanna, which it crosses about three miles above the town of Milton. A much longer and more important anticlinal axis, which has elevated a beautiful and fertile belt of limestone, passes one mile north of Boalsburg, in Penn's valley, and extends along Brush valley, pursuing the northern side, generally within half a mile of the base of Nittany mountain. It upheaves the strata of formation II, which dip at a moderate angle, rarely exceeding twenty degrees. Running eastward, this line of elevation enters the middle of Buffalo mountain, which it traverses to its termination. It afterwards emerges into Buffalo valley, where it inclines the red shale rocks of formation V, and runs to the Susquehanna near New Columbia. Brush valley varies between one and two miles in width, is remarkably level, owing probably to the gentleness in the dip of its strata, and is one of the most beautiful in the district. In consequence, probably, of the same cavernous character in the limestone, which exists to so great an extent in Nippenose valley, there is little or no water to be procured below the soil, in many parts of this valley, by wells, and the inhabitants have been constrained to conduct it to their dwellings in pipes from the adjacent mountains. Brush mountain, consisting of all the three divisions of formation IV, is composed of three ridges, in consequence of a synclinal axis passing along its centre. This trough in the dip of the rocks, continues eastward into Buffalo valley, and extends westward into one of the Seven mountains at Boalsburg, passing a fourth of a mile north of Old Fort.

In Penn's valley, we can trace one anticlinal axis running between Egg hill and Brush mountain, and a second lying further south between Egg hill and the Seven mountains. The more northern of these lines of elevation, may be found about a fourth of a mile from the foot of Brush mountain, near Millheim, and can be followed thence to where it passes about one mile south of the Old Fort, and onward until it enters the middle of a high knob of the mountain ending at Boalsburg, being there but a short distance south of the synclinal axis that extends from the middle of Brush mountain. Towards the east, it has produced the valley in which Pine creek flows, and which lies between the Short mountain and Brush mountain, forming a northern branch to Penn's valley. From the end of this narrow valley, its course is through the ridge which terminates at the gap or entrance into the Brush valley narrows, whence it probably extends to the Susquehanna, crossing a quarter of a mile below Milton bridge.

The Short mountain is composed of three ridges, being a mountain of synclinal structure. This trough is continued under Egg hill, and thence into a ridge which rises from the valley about five miles east of Boalsburg.

Following the anticlinal axis of George's valley, eastward, we trace it into Penn's valley narrows, between the Short and Seven mountains, and thence into a mountain which ends nearly three miles eastward of Hartleton. Westward, this line of elevation in the strata passes into what is called the Loop, and thence directly through the Bear meadows, and out into Stone valley.

Notwithstanding the seeming complexity in the geological structure and topography of the Seven mountains, this range is extremely simple. Crossing it, for instance, on the Lewistown and Bellefonte turnpike, we discover the following features in the dipping of the strata, which belong to the three sub-divisions of formation IV.—After leaving Penn's valley, the dips are first south, then north, showing a *synclinal* axis, and further still we meet a second change to a north inclination, giving proof of another *synclinal* axis. Passing over these last north dips, we reach the bold anticlinal axes, which have brought up to the surface the limestone strata of formation II, in Kishacoquillas valley. The trough or *synclinal axis*, first met with south of Penn's valley on entering the Seven mountains, passes into Buffalo valley north of Paddy's mountain. This mountain contains an anticlinal axis, the same which forms the middle ridge of the Seven mountains. The southern synclinal axis or trough in the Seven mountains may be traced through Buffalo valley, along the middle of Limestone ridge, to the Susquehanna, nearly three miles south of Lewisburg, whence it may be prolonged immediately to the south of the anticlinal axis of Montour's ridge, though it probably dies out at the river. The axis of elevation just mentioned, after leaving Montour's ridge, continues westward in Buffalo valley, and dies out between Paddy's and Jack's mountains.

Kishacoquillas valley, a limestone valley of great beauty, and interesting for the abundance and purity of its iron ores, contains probably three anticlinal axes, though only two are traceable beyond it, north-eastwardly into Buffalo valley. One of these axes of elevation passes between the Seven mountains and the northern knob, which closes the valley towards the north-east. This knob contains a synclinal axis or trough in formation IV, and includes near its end three ridges, and further eastward four, by the forking of the middle ridge, which consists of the upper or white sandstone member of formation IV. The most northern of the two inner ridges, after running some distance, is joined by a similar ridge from the southern part of the Seven mountains, and the two closing into one mountain, form the White mountain with an axis of anticlinal structure. Its axis is prolonged through Buffalo valley, where it may be traced along Penn's creek, and further still into Longstown ridge. The point at which it is finally exhausted, or, what is the same thing, where the uptilted strata finally flatten down or change their dip, is not yet exactly known. The anticlinal axis which extends along the south-east side of Kishacoquillas valley, passes eastward between another knob at the head of the valley and Jack's mountain. The upper strata of these two close together over this line of elevation, which thence runs through the centre of Jack's mountain. This ridge has, therefore, a simple anticlinal structure from hence to its termination, two and a half miles west of New Berlin. At this point of the mountain it has gently elevated the shaly strata of formation V, affording us an opportunity for finding the fossiliferous iron ore, not only around the end of Jack's mountain, but along both the northern and southern flanks of the ridge, should it exist here in any conspicuous quantity.

Having endeavored in the foregoing account of the Geological structure of the parts of Union, Lycoming and Centre counties explored during the past season, to convey, as far as my present limits allow, some conception of the mode in which the formations in this quarter of the State are distributed, I shall conclude what I have to say on the third Geological district, by describing, as briefly as possible, the several belts of formation V, in its range between the Susquehanna river and the Maryland state line. I am induced to do this from a persuasion of the great importance to our iron manufacture in these counties, of the fossiliferous iron ore which occurs only in this fifth formation. I wish also to place on record at this time, some information respecting the range of the ore, in the hope that it may prove useful in directing the researches of the proprietors of furnaces, and others interested in the discovery of the mineral. The detailed and systematic examination undertaken for this highly valued species of iron ore, consumed a considerable portion of our season in Buffalo and White Deer Hole valleys, and the valley of the West Branch and Bald Eagle creek from Muncy to Bellefonte. Hereafter, it will be extended to every belt of the red and variegated shales which offer any reasonable indication of containing the fossiliferous ore. It may be expedient, in the mean while, to state results of various reconnoissances in parts of the district not yet accurately surveyed, by which the wide distribution of the ore has been established, and the directions in which it ranges at least approximately ascertained.

Before tracing the course of formation V, it may be useful to call attention to the part of the stratum, in which the fossiliferous ore occurs, referring for more minute details to my second annual report The whole stratum, consisting of red and variegated shales and red sandstone, is susceptible of a natural sub-division into three members. The lowest of these is a dense and heavy sandstone of a dark brown color, having a decided tendency in its fragments to assume a square or cubical form. The middle division is made up of layers of shale or soft slate of various tints, the more usual colors being dull olive, bluish grey, yellow or buff, and dingy brown. Some of these layers, especially the olive colored ones, are often covered with the impressions of shells and other fossils. In this part of the stratum, those are also occasional thin bands of limestone, generally highly fossiliferous layers, that the bands of fossiliferous iron ore occur in, whenever they are present. The upper sub-division of the stratum, is a rather thick mass of red or rather brown shale, of very crumbly texture and uniform aspect.

Upon formation V, the next in the order of stratification, is the blue fossiliferous limestone stratum, formation VI, of the series.

In consequence of formation V reposing on the great sandstone mass, formation IV, its lower and middle beds will be found to be almost invariably upon the flank, or at the base of the high mountain ridges, consisting of the latter stratum. This will always be the case, when the inclination of the rocks is considerable. In those instances where all the strata of the mountain dip, in one direction, for example in Bald Eagle mountain, the ore bearing stratum or formation V, will be found only on one side of the ridge, namely: the side remotest from the anticlinal axis, which has produced the elevation of the mountain, which being here the Bald Eagle mountain, the axis is that of the Nittany valley. But in other cases, where an anticlinal axis passes along the summit of the ridge, composed of formation IV, or in other words, where the rocks dip in both directions from the middle of the mountain, then there occur two belts of the ore, or at least of the stratum in which it alone exists. Such is the structure of Montour's ridge, in Columbia county, where a distinct band of the ore occurs along each flank, running for a distance of many miles. A similar conformation prevails in Wills' mountain, in Bedford; Jack's mountain, in Huntingdon; Shade mountain, in Mifflin and Union; and Tuscarora mountain, in Perry county. The presence of the ore is indicated along nearly all of these ridges, but too little has hitherto been done in the way of a systematic exploration, to authorize my entering here into any further particulars, than to trace out the course of the formation which should contain the ore.

Commencing with its most north-westerly belt in the district, and indeed in the State, we can trace formation V from the eastern end of Bald Eagle mountain, along the north-west side of that ridge, at the base and upon the flank of which it reposes throughout its entire course, to its south-western termination near Hollidaysburg. In all this distance, the dip of the stratum, with a very few local irregularities, is towards the north-west, with various degrees of steepness. Here passing round the point of the mountain, the formation spreads out as far as that town, when the fossiliferous ore is sometimes met with in excavations, but its want of thickness, and the excess of calcareous matter which its numerous fossils give it, have prevented its becoming an object of economical interest. From Hollidaysburg, the formation containing the ore having doubled round the end of the Bald Eagle mountain, which is here called Brush mountain, ranges north-eastward to the head of Canoe valley, at the junction of the true Brush mountain with Canoe mountain. In this portion of its course, the prevailing dip of the stratum is towards the south-east. From the head of Canoe valley, it courses to the south-west, along the north-west base of the Canoe or Lock mountain, running into the little cove of Old Town run, thence north-westward towards Frankstown, before reaching which it folds round the end of Dunning's mountain, (here called Lock mountain,) and pursues from this point southward, the western flank of that mountain, to its termination about eight miles north of Bedford. Folding round the spur which Dunning's mountain here throws forward to the south, one belt of the formation, obeying the flexures of the mountain, sweeps round the margin of the valley, termed the Dutch corner, and continues its course thence along the western base of Evitt's mountain, (the prolongation of Dunning's mountain,) to the Maryland State line. The other belt passes on towards the south-west, or if interrupted, it is only for a short distance, and encounters the northern end of Wills' mountain. In virtue of the anticlinal structure of that ridge, the belt is here divided into two, one taking the eastern base of the mountain along the Cumberland valley, the other the western base, following the valley of Wills' creek. Both of these tracts of formation V, cross the Potomac into Virginia, whence they are prolonged more than one hundred miles in connexion with the same great anticlinal axis. From information derived from the State Geologist of Virginia, Professor William B. Rogers, the same valuable fossiliferous iron ore, which imparts such interest to this formation in Pennsylvania, still accompanies the stratum, being met with in beds from six to eighteen inches in thickness, and of very pure composition.

As an evidence of the probable continuousness of the ore throughout the long tract between the Susquehanna and the Potomac just traced, it is proper to mention that a bed of sufficient thickness for valuable purposes occurs in Dutch corner, and one has likewise been found near Frankstown, where the ore is used, making a very excellent iron.

Commencing at our former point of departure, at the eastern termination of Bald Eagle mountain, on the Susquehanna, we may trace the formation in a very irregular and winding tract south-east of that already described. This belt extends from the river, with a south-eastern dip, along the south branch of the Bald Eagle mountain, to the head of White Deer mountain. Folding back, it doubles round the end of this mountain axis near Watsonburg, entering Buffalo valley, over the surface of which it expands itself as previously described. The lower beds of the stratum take a winding course round the margin of the valley, running up a short distance into the valleys which head between the several anticlinal ridges that project themselves forward into the main valley, and doubling round these, where they die away upon the plain. Following this curving course, these rocks reach the head of Buffalo valley, whence we may trace them eastwardly by the valley of Penn's creek, with a north dip resting against the base of Jack's mountain. Sweeping round the eastern end of that mountain, they assume a change in their dip to the south, conforming to the axis of elevation in the middle of that ridge. The belt next runs south-westward along the south-eastern foot of Jack's mountain, obeying the gradual flexure of the ridge until it reaches its southern extremity in Huntingdon county. This mountain containing an anticlinal axis at its south-western end, as it does at its other extremity in Union county, the overlying stratum, formation V, mantles round the terminating knob, as it must round that of every similar anticlinal ridge, composed of formation IV, and taking an altered dip to the north-west, it follows the western flank of the mountain, and its continuation, Stone mountain, to the head of Stone valley. The border of this valley being diversified towards its upper end, by several mountain knobs protruding themselves into it from the north-east, these short and rapidly subsiding ridges, as we have already beheld in a strictly analogous case in Buffalo valley, deflect the course of the formation which runs invariably along their base, and give it a rather winding course, causing it to fold round their points and to re-enter between them, until we reach the south-eastern base of Tussey's mountain. Resting against that flank of this bold ridge, with a rather gentle south-eastern dip, we may trace the formation westward to the Little Juniata, where it is finely exposed, and follow it thence along the eastern base of the same mountain, through Hartslog and Woodcock valleys, and the same regular line of valleys prolonged to Maryland.

In several parts of this long and crooked belt, the fossiliferous iron ore has been already met with in bands having a thickness and a purity of composition, such as to awaken cheering anticipations concerning the general productiveness of the formation in regard to ore. Thus it has been found near Drake's ferry at the base of Jack's mountain on the Juniata, where it displays uncommon purity, and it has been rather extensively developed in Woodcock valley. in three parallel and contiguous beds, when, by the enterprise and knowledge of George Thompson, Esq. it was applied several years ago in making iron, and is much used in some of the neighboring furnaces.

Another long and narrow tract of formation V, lying to the south-east of the former, commences at the Susquehanna at Selinsgrove. Extending thence towards the south-west, its lower beds gradually rise as we advance, in consequence of an anticlinal axis which we can follow into the end of Shade mountain. At this point the belt of formation V divides one branch with a north-west dip, keeping the north-western foot of that mountain, to Lewistown, where, after doubling round the end of the mountain, and entering the long narrows of the Juniata, it resumes its south-westerly direction along the flank and base of the mountain, which here takes the appellation of the Blue Ridge. Passing a few miles beyond the southern termination of this ridge, nearly to Shirleysburg, it is again deflected somewhat to the east; for the strata suddenly, as in all cases when opposite the end of a mountain of anticlinal structure, change their course and run north-eastward some distance into Sugar valley, their dip here being to the south-east. In that valley the formations lie in a synclinal trough, resting between the Blue Ridge and Black Log mountain, along the western base of which last, the strata stretch forward once more towards the south, with a western dip as far as the southern termination of the mountain. At this point, when the dying out of the anticlinal axis, which has brought up the limestone, formation II, in Black Log valley, has brought together the Black Log and Shade mountains, the ore-bearing stratum, formation V, folds as usual round the end of the knob, and taking a north-eastward course, ranges along the base of the Shade mountain, to where it ends at Licking creek. Folding in an anticlinal axis over the point of this ridge, it changes, of course, its previous south-east dip to a north-western one, and ascends the valley of Licking Creek for a few miles in the form of a synclinal trough, where it pursues its former direction, dipping once more to the south-east and conforming in its course to the south-eastern base of the northern Shade mountain, until it leads us eastward beyond the end of this mountain, to our original point of departure at Selinsgrove.

In many parts of its course, this double belt of formation V gives indications of containing the ore, in bands of sufficient magnitude, to inspire the hope that a minute and systematic survey of the stratum, may disclose it in valuable qualities. At the eastern termination of the Long narrows of the Juniata, where the beds of this rock rests at a high inclination against the foot of the Shade mountain, a seam of the fossiliferous iron ore has been detected of a thickness and quality, nearly if not quite adequate to render it highly useful.

The beautiful and rather fertile little oval valley in the southern part of Bedford county, near Hancock, called Pigeon cove, is based upon formation V, being encompassed on all sides by a belt of hills, containing the fossiliferous limestone, formation VI, and the sandstone, formation VII; but whether the rather flat, anticlinal axis which has upraised the red and variegated shales of formation V, has also brought up to the surface, that part of the formation in which the fossiliferous ore ought to occur, is a point demanding further research. The axis of elevation in Pigeon cove, is almost precisely in the prolongation of the extensive anticlinal line, which upheaves the limestone, formation II, in Black Log valley. They may be traced almost continuously into each other, by observing the dip of the strata. The next important range of formation V, extending through our district, commences at the west side of the Susquehanna, nearly opposite Georgetown, and runs through Pfouts' valley, to where it divides into two belts, at the eastern end of Tuscarora mountain. Here the anticlinal axis of that ridge has protruded the rocks of formation IV, which form the mass of the mountain. After separating at this point, which is a few miles east of the Juniata river, one belt pursues its course to the south-west along the north-western flank and base of the Tuscarora mountain, the curvatures of which it follows as far as Sidney knob, in Bedford county. On the western side of that ridge the formation disappears in consequence of an enormous dislocation of the strata, which, commencing in this vicinity, runs southward along the western foot of Scrub ridge, tilting its strata and those of the adjacent side of the M'Connelstown cove, (composing formations III and II,) which it borders, into an inverted position and burying the rocks of our formation V, and also the overlying formations VI, VII, and VIII, so that the strata of formation IV, actually lean in some places upon those of formation IX. This has thrown down the ore-bearing shales of formation V, to a depth of probably not less than three thousand feet below the surface, which they would otherwise occupy.

Further to the south, in the neighborhood of Hanover furnace, the dislocation seems to become less and these rocks once more emerge to the surface, forming a narrow belt in which their strata are greatly crushed. This, however, after a course of a few miles, crosses the State line, and finally, the Potomac river below Hancock.

The other belt of formation V, taking the south-eastern side of the Tuscarora mountain, ranges with south-eastern dips along its base, through Raccoon valley, and in the same general course, follows the mountain nearly to the line of Perry and Franklin counties. There the stratum is caused to curve much about, sweeping round the points of the high ridges in that part of Perry and winding into the short valleys between these knobs. It then stretches eastward until it nearly reaches the town of Bloomfield, and thence ranges south-westward, meeting finally, after several meanderings, the northern base of the Kittatinny or Blue mountain, near Wagner's gap. From the latter point it follows the northern slope of this mountain, to the Susquehanna, whence it ranges north-eastward as described in my last annual report, resting at the base of that ridge until it leaves the State, near the Water Gap of the Delaware river. Fragments of iron ore, indicating the probable existence of the fossiliferous band, were picked up at several points when making the reconnoisance of

Perry county, but in the belt which stretches from the Susquehanna to the Delaware, along the base of the Kittatinny mountain, notwithstanding a diligent examination has been made, no symptoms of its presence in any quantity have been discovered. Its absence from this, which is the most south-eastern tract of the formation, is probably attributable to the almost total deficiency of the variegated calcareous and fossiliferous layers in the middle of the stratum, with which the ore would appear to be invariably connected.

The only other exposure of formation V, in the State, is upon Montour's ridge, and here the fossiliferous ore is largely developed and at present somewhat extensively worked. A general account of it, sufficient for the present purpose, was offered in my last report. In closing this chapter upon the third Geological district of the State, I would observe that the reader is by no means to infer that the formation thus extensively distributed, and which I have approximately traced, is the only one besides the great blue limestone, formation II, that holds out a promise of containing iron ore in sufficient deposites to warrant a minute exploration. Valuable ores peculiar to each stratum, are often found and occur sometimes rather abundantly, in connexion with formations VI, VII, VIII, IX, and XI, and with the coal measures of Broadtop mountain, embraced within this district. By following up the detailed investigation of all the strata of the region upon the plan already commenced, we hope ultimately to offer to the manufacturers some valuable facts concerning the best clue to the position of these ores. General practical rules in relation to the distribution of so important a mineral if discoverable, are of inestimably greater benefit to the public, than almost any number of merely insulated discoveries, and that they are often attainable by the aid of careful observation and science, must be conceded by every one at all experienced in mining and Geological research.

CHAPTER III.

A GENERAL SKETCH OF THE OPERATIONS OF THE SURVEY IN THE DISTRICTS NORTH AND WEST OF THE ALLEGHENY MOUNTAIN.

SECTION 1.

That part of Pennsylvania which lies to the north and west of the Allegheny mountain, comprising about one half of its territory, exhibits a remarkable contrast to the Appalachian chain which I have been last describing, both in respect to its Geology and its Topographical structure. The strata of its rolling surface belong only to the four or five uppermost formations of our great lower secondary series, whereas, in the Appalachian region, we are presented with every rock of the entire group, from formation I, to the coal measures or formation XIII, inclusive. Here those two great natural agents which have given to every part of our country, all that is peculiar to it in its external Geological and Geographical features—I mean the subterranean forces and the superficial ones—has evidently operated with far less intensity than in the disturbed mountain chain which borders this region on the south-east. In the country which I am now about to describe, the inclination of the rocks is much less, and the changes in the direction of the dip more rare; in other words, the anticlinal axes are flatter, fewer and wider apart, though they preserve their general parallelism. The operation of currents upon the strata would also appear to have been more gentle and evenly diffused, and individual strata have been preserved from destruction, and keep their position near the surface over far wider areas, than in the other region, so that whatever useful mineral deposites they may contain, such as beds of ore or seams of coal, will be found spread out over an extent of country so great, as hardly to be credited, unless we advert to the causes which have occasioned their being thus diffused. One of the most fortunate circumstances for the resources of this portion of the State, arising out of its peculiar Geological structure, is to be found in the universally rolling outline of its surface, which is every where trenched by ravines, and by more or less deep valleys, the results of an extensive denudation by water. This feature gives us ready access to the strata and all their contents, which lie above the lowest water level of the country, imparting superior exactness to our explorations by the facility afforded for inspecting and measuring all the beds. In entering upon a brief, general description of the mode in which the mineral wealth of this part of our state is diffused, a hasty outline of its leading Geological features will prove a useful introduction to the details which are next to follow.

Taking a comprehensive view of its stratification, the whole of this north-western half of the State has the structure of an extensive basin, or more properly it is the termination of a more enormous basin, which stretches south-westwardly from Pennsylvania to the northern border of the state of Alabama. From the southern boundary of the State, in Somerset county, to the North Branch of the Susquehanna, in Luzerne, the south-eastern base of the Allegheny mountain constitutes a remarkably well defined margin, separating this region from the Appalachian chain. Between that limit and the shore of Lake Erie, on the north-west, and the state of New York, upon the north, the strata all belong to formations VIII. IX, X, XI, XII and the coal measures or formation XIII. The two lowest of these rocks, formations VIII and IX, ranging along the south western foot of the Allegheny mountain, between the points already designated, sweep in a wide curve round the eastern terminations of the upper rocks in Susquehanna and Bradford counties, and are traced westward in a long belt, parallel with the northern line of the State, from Towanda to the state of Ohio. Immediately within the long zone thus delineated, we perceive a bold escapement formed by the hard sandstone strata of formations X and XII, being the actual margin of the great bituminous coal basin.

On the south-east this escapement is the ridge of the Allegheny mountain, but on the north it is a more undulating chain, of more broken outline, which stretches from Towanda, almost due westward by Blossburg, Smethport and Warren, and thence with a greatly reduced height, is deflected somewhat to the south by Meadville and Greenville, until it crosses into Ohio. Along the northern side of the basin, from formation VIII upwards in the series to the coal measures inclusive, the strata have a gentle dip towards the south, leading us into higher and higher beds of rocks, as we recede in that direction from the New York line, where the slate and argillaceous sandstones of formation VIII, form the predominant rocks. In

Crawford and Mercer counties, where the lower strata lie to the north-west of the coal, the prevailing dip of all the rocks of the series is towards the south-east, but along the Allegheny mountain, or on the south-eastern margin, their prevailing inclination is either north-westward or northward, being thus in every case inwards, as respects the central portion of the great trough enclosing the coal. But while this, as a general rule, holds strictly true of the strata along the edges of the basin, it is necessary that we should observe, that within this boundary there exists a number of anticlinal axes, some of them of great length and elevation, others low and insignificant, which give to the strata throughout nearly the entire region, an almost endless succession of more or less gentle undulations. As those axes of elevation have lifted the formations that lie below the coal to the surface, even causing the latter to be swept away entirely, over many considerable tracts of country, and as they in fact divide the whole region into a series of insulated and subordinate coal basins, the exact limits of which it is important I should mention, I shall briefly describe the position and range of such of those as our researches have brought to light, specifying some details about the strata in the several basins which they enclose.

SECTION 2.

Of the fourth district, embracing the country included between the base of the Allegheny mountain and Chesnut Ridge.

Nearly all of the anticlinal axes which are of sufficient magnitude to impress decided features on the topography of the region, or to have caused the removal of the coal measures from along this line, range in a north-east and south-west direction, or in lines parallel to the course of the Allegheny mountain, and are embraced within a belt of country rarely exceeding forty miles in width, measured north-westward from the base of that escarpment.

Beginning with the southern end of this belt, where these anticlinal axes, and their included troughs containing the coal measures are best defined, and where our explorations as far as relates to the south-eastern counties of the great coal field, have been more detailed than further north, the anticlinal axis which first meets our attention, west of the eastern margin of the coal, is one which occurs midway between the Savage and the main Allegheny mountain in the south east corner of Somerset county. This is probably a prolongation of that which ranges along the summit of Chesnut ridge, in Bedford county, where it has brought to the surface the limestone and sandstone formations, VI and VII. As it ranges towards the south-west, it exposes the rocks of formation VIII, which form a long wedge-shaped belt, ending near the line of Southampton township. From this point, where the belts of formation IX, on each side of it, have coalesced into one, this latter stratum alone occupies the depression between the two mountains above named, a less extensive denudation of the rocks which fold over the axis, having taken place towards the south of the two separated edges of the higher formation X, which forms the ridges of the great Allegheny and Savage mountains. These unite, and as we approach the Potomac, they compose but one mountain, along whose summit we may still trace the prolongation of this anticlinal axis. It is this axis of elevation which, together with that of Wills' creek mountain, (the westernmost of those in the Appalachian region, to the east,) forms the highly interesting and important coal basin of the Potomac. This basin, commencing towards the head of Stone run, in Hardy county, Virginia, ranging through Maryland and terminating at Wills' creek, in our own State, is here bounded on the east by the little Allegheny, and on the south-west by the Savage mountain. The Pennsylvanian portion of this basin may be estimated at five miles in width, measured along the State line, and seven in length. It is believed that no coal will be discovered to the north-east of Wills' creek, as from the close approximation of the bounding ridges, the coal measures have there been much exposed to denudation and carried off. Of the coal veins enclosed within this trough, the highest in the series is that which is principally worked. It extends with a very undulating line of outcrop near the summit of a long irregular ridge of considerable elevation, lying about midway between the little Allegheny and Savage mountains. Numerous transverse valleys of denudation intersecting the ridge, have interrupted the regular range of this upper coal seam, rendering it difficult to compute the area which it actually occupies, but favoring greatly the operations of the miner, by exposing a more extensive out crop. Its average thickness, as ascertained in numerous places where it has been opened, is about eight feet, the most extensive mine being that of David Hoyman, about a mile north-east of Jenning's run.

The identity of this with the great seam worked at Frostburg, in Maryland, is highly probable, as well from the character of the coal itself and the accompanying shales, as from the similarity of its position upon the ridge. Several other good seams are known, situated lower in the series, in thickness from three to five feet, but being less accessible and important than the one above, and there being at present but a small demand for coal in this neighborhood except for local use, they have excited but little attention. Iron ore of excellent quality was collected by us on the surface, at many points in the basin, and there is reason to believe will be found in ample quantities especially associated with the shales of the lower seams, whenever the proprietors of the soil shall deem it of sufficient consequence to undertake the requisite diggings. Between the coal seams there occur two or more thin bands of limestone sufficiently abundant to use as a flux or for agricultural purposes. The tract included between the Savage and Allegheny mountains, containing formations VIII and IX, thrown up by the anticlinal axis previously traced, presents but little that is interesting in regard to its mineral resources. The rocks of the Allegheny mountain thrown into north-west dips by this axis, are thus made to constitute the south-eastern margin of another basin, whose north-west boundary is defined by the rocks of the Negro mountain, which have received a contrary dip to the south-east, by an axis passing through the centre of that ridge. The broad and flattened axis of Negro mountain, exposing formation X on its summit and over its gently inclined flanks, is prolonged to the north-east, at least as far as the Bedford and Stoystown turnpike. Along this elevated belt, therefore, the coal-bearing rocks have been removed, and at the same time the influence of this axis, by elevating the strata in the middle of what would have been a broad and deep basin, between the Allegheny mountain and Laurel hill, has rendered the two minor basins into which it has divided that space comparatively shallow, and removed much coal.

A tract of rather low ground follows the north-western base of the Allegheny mountain, in the southern part of Somerset county, from which the coal measures appear to have been removed by denudation, but the coal almost invariably occurs in the first range of hills further towards the centre of the basin. Thus in the vicinity of Salisburg, little or no coal is indicated between the mountain and Castleman's river, while it is abundant in the higher lands to the west of that stream. In this neighborhood, as in the south-east basin before described, the best developed coal seam is the large one, being here from eight to nine feet in thickness. Though traceable over a considerable extent of country, it has hitherto been opened in only a few places, there existing at present but little inducement for mining the coal, secluded as it now is from market. The lower and thinner coal beds, and the iron ore often associated with them, have therefore been still less sought for, and are scarcely known. Advancing northward to the neighborhood of Berlin, we there no longer meet with the upper or larger seam, a deeper denudation of the strata having washed it away, but the lower seams have been wrought near the town to some extent, for the supply of Berlin and Somerset. At this place the seams which are mined are three in number, the uppermost affording about five feet of true coal, the middle one, considered the best and hence most worked, about four feet, and the lower one, recently opened, about three feet. The space between the upper and middle beds measures about sixty feet, that between the middle and lower beds from forty to fifty feet.

In some of these shales between the coal seams, cccur thin flaggy bands of *iron ore* of considerable purity, being an argillaceous proto-carbonate of iron. There likewise exists a bed of limestone nearly three feet in thickness. Iron ore prevails about Elk Lick creek, near Castleman's river, and may be observed in many places along the north-western declevity of the Allegheny mountain.

Near the base of the same ridge, bog ore may also be frequently found, but the deposites rarely give evidence of a large supply. The occurrence of one or more layers of limestone in the strata between the lower coal seams, is an usual feature in nearly every part of this basin, and from the inestimable value of lime in agriculture, it is to be regretted that more frequent use of it is not made.

Between the north-western slope of the Negro mountain, and the south-eastern slope of Laurel Hill, occurs the next trough of coal measures. These upper strata dip gently to the north-west, from the former of these ridges, and at about the same inclination to the south-west from the latter, conferring upon the valley between them, the structure of a regular synclinal basin, of rather wider and deeper dimensions, as respects the coal containing rocks, than that embraced by the Negro and Allegheny mountains.

The townships of Addison and Turkey Foot, lying within this trough, have a rough and hilly surface, intersected by streams, which run in deep gorges between the hills. Towards the centre of the basin, the seams of coal usually occupy a low position, being rarely exposed, but in the deep ravines and near the borders of the streams, a coal seam six feet in thickness, is found low down on the banks of the Youghiogheny, near Smithfield, from which a considerable quantity of coal is derived for the supply of that town.

The exact position of this bed in the series and the relative situation therefore of the other seams to it, has not yet been ascertained in this neighborhood, but further research, it is hoped, will make these matters clear. Iron ore exists in many places within this basin, and could probably be procured in ample supplies, for the manufacture of the metal, especially towards either border of the distiict, if those who are interested would embark in some systematic diggings, among the slates connected with the lower coal seams. About Drake's run, and from thence towards the head of Laurel Hill creek, it would appear to prevail in great abundance, and much of it to be of excellent quality, but occurring in a wild and uninhabited region, it has been but little sought after. Near the head of Garey's run, it is procured for the use of Rogers' furnace, to which it is taken to the western side of Laurel Hill. Exploring the country northward towards Milford and Somerset, we find coal abundant in the hills lying west of Castleman's river, but extending our researches still further north, we observe the surface of the country gradually to rise and to be less intersected by the valleys and ravines, so essential to the full exposure of the strata, and as a consequence, the indications of coal become more rare. Between Somerset and the base of Laurel Hill, very little coal can be detected, though the probability, if we judge from the dipping of rocks and other indications, is great, that the main coal seams have not been washed away, but lie buried beneath the more unproductive strata that occur near the surface. The same remarks are true of the country north of Somerset, until we descend to a considerably lower level along the waters of Stony creek and Quemahoning, where we again find the coal. In this position, it occurs near Stoystown, and further westward, and also eastward on the other side of the prolongation of the Negro mountain axis, which is here greatly reduced, or possibly, entirely flattened down; and again, on the flank of the Allegheny mountain, at Statler's, on the Bedford and Stoystown turnpike. This vanishing of the Negro mountain axis, causes the whole valley between the Allegheny mountain and Laurel hill, to have the structure of a single basin, and from Stoystown northward, I shall speak of it as one. Iron ore, apparently of fine quality, is found along Stony creek, above Stoystown, and also in many places near the foot of Laurel hill, on the head branches of Quemahoning. That at the old Shade furnace is rough and sandy. This furnace has not been in blast for some years. From the vicinity of the turnpike above spoken of, north-eastward to the Conemaugh, the country is rugged and unsettled, except in a few spots in the neighborhood of Paint creek. Near the mouth of that stream, and along the valley of Stony creek, where some population prevails, the beds of coal are again recognized and have been partially mined at a few points, to supply the blacksmiths and others in the district. The digging of the coal being performed, as in most other similar places, during the winter, and carried on upon a very small scale, the spring thaws cause the earth and slates to fall, rendering the entrance to the mines inaccessible during the summer. We are hence, too frequently precluded from ascertaining the thickness, quality and aspect of the seams, and from procuring those other data, so essential to any attempt to trace and develope the coal over the circumjacent country.

The deep valley of the Conemaugh, exposing the strata from the uppermost beds of the coal series, in this part of the basin downward to nearly the bottom beds of formation XI, we are enabled, through a careful examination of the denuded beds, to determine with some accuracy, the contents of the coal formation in this portion of its range. The artificial excavations along the line of the Portage rail road furnish, from point to point, displays of the stratification, which greatly assist the investigation. Using the facilities thus afforded, we collected an ample suite of specimens from the strata composing the coal measures, together with a set from the underlying beds of all the formations, included between the base of the Allegheny mountain and the first bed of coal. Minute measurements were at the same time instituted, which will enable us to approximate to the thickness of all the strata, between the foot of the mountain and the third principal coal seam, which rests upon its summit. The same was done in the gap at Laurel hill, where the Conemaugh, passing through that ridge, presents an excellent opportunity for collecting those details of the stratification, which, when applied to other neighborhoods, where the rocks are more obscurely discovered, greatly assist us in tracing any valuable beds which they may contain.

In the vicinity of Johnstown, there are known at present, three seams of coal, the lowest occurring only a few feet above the level of the Conemaugh. The next is between forty and fifty feet higher in the strata, and has immediately beneath it a stratum of limestone, varying from three to eight feet in thickness. Between sixty and seventy feet above the middle coal bed is another, apparently the uppermost workable seam in this vicinity. These coal beds are respectively three, three and a half and four feet in thickness. They are but little worked, supplying only the immediate neighborhood. The mines adjoining the rail road on the Allegheny mountain, furnish fuel to the stationary engines at the inclined planes, and supply a moderate demand from the country east of the mountain. The measurements and other researches undertaken, indicate that most, if not all these mines near the rail road, are in the uppermost of the three seams already mentioned, excepting the mine of Dr. Shoenberger, near the foot of Plane No. 6, on the eastern descent of the mountain, which would appear to be in the lowermost bed in the series.

Passing from the valley of the Conemaugh towards Ebensburg, the surface of the country rises rapidly, and the principal coal seams are again lost to view, beneath the unproductive superincumbent strata, which here spread themselves over the surface. Some small beds from one to two feet in thickness, are however met with. Towards the eastern and western borders of the basin near the base of the Allegheny mountain and of Laurel hill, the lower and thicker beds occasionally show themselves, and admit of being extensively traced.

Among the slates included between these seams, we find as usual, the chief deposites of argillaceous iron ore, the display of which is particularly promising along Laurel run and Hengston's run, which flow southward into the Conemaugh, near the foot of Laurel hill. Ore is also to be found along the waters of Clearfield creek, and in other places, near the western slope of the Allegheny mountain, between eight and ten miles south-east of Loretto.

Northward from Ebensburg, the country descending in virtue of the drainage towards the Susquehanna, we once more cross the out crop of the coal, though in this truly wild forest region, but very little excavation has been attempted. The Laurel hill loses its features as a distinct ridge, a little south of Blacklick creek, the anticlinal axis to which it owes its elevation and structure, being hardly discernable in the deep gorge through which this stream flows across its termination. Some miles south of this point, the height of the ridge being much reduced and its axis greatly flattened down, the coal slates and the coal itself reach high up on the irregular but gentle slope of the hill. At the extremity of the ridge, coal is found in abundance exposed in the valley of Blacklick creek, whence it is taken chiefly to the town of Ebensburg. Iron ore also occurs, and a considerable amount of excavation has been made in search of it, on the north bank of the same stream, through the enterprise of Messrs. Lewis and Rogers of that town, and with encouraging prospects. About two miles lower down the stream, borings were made some years ago into the strata and salt water obtained, but the manufacture of salt was abandoned. Recently, operations in this place have been recommenced, by Judge Murray, of Cambria county, whose workmen, during the autumn, were engaged in increasing the depth of the wells.

The next coal basin of which I propose to offer a brief sketch, is the long synclinal valley, enclosed by Laurel hill on the south-east, and Chesnut ridge on the north-west. A straight and very regular anticlinal axis, extending along the centre of each of those important ridges, the rocks on the north-western side of the Laurel hill are made to dip towards the north-west, while the same strata appearing along the south-eastern base of Chesnut ridge, incline in the contrary direction, or towards the south-east, giving to the whole belt the structure of a regular trough. To this feature, we owe the preservation of the upper or coal bearing rocks, which have been swept entirely away, from the denuded flanks and summits of the two bounding ridges. It may be well to mention in this place, that a singular degree of confusion prevails in regard to the name of these ridges. From its north-eastern termination, to the break or notch by which the Youghiogheny passes through it, the western ridge is every where styled the Chesnut ridge, but from that point southwestward into Virginia it often, though incorrectly, receives the name of Laurel hill. In my descriptions, I shall apply the name of

Chesnut ridge to this axis throughout its entire length, and reserve that of Laurel hill for the mountain which ranges parallel with it on the south-east, at an average distance of twelve miles.

In the western corner of this coal basin, included between these ridges and bounded by the State line and the National road, some of the coal seams show themselves, being mined in a few places on a small scale, for fuel for the blacksmiths. On the bank of Sandy run, a little north of Elliott's mill, there occurs a natural exposure of iron ore, which, from the apparent quantity of the mineral, deserves attention. The eastern side of the valley, towards the base of the broad flattened ridge of Laurel hill, comprises a wild, barren country of sandy hills and swampy glades, offering nearly insuperable impediments to Geological explorations. Near the eastern base of Chesnut ridge, about a mile and a half south of the National road, on a tributary of the Sandy run, there exists a quantity of good iron ore. It has been extensively explored by Andrew Stewart, Esq., who has lately erected a furnace for smelting it. A little north of the National road in the same range, ore is extensively dug, being transported across the mountain, to be smelted in Huston's furnace, near Uniontown. Between the National road and the Youghiogheny, the country is generally covered with forest and is very rough and wild, becoming towards the river exceedingly broken and hilly.—Seams of coal and layers of iron ore, are here found. The ore is used in two or three furnaces in the neighborhood of Laurel run on the south, and of Saltlick creek on the north of the Youghiogheny. Other furnaces formerly in operation here, and to the north towards Ligonier and Laughlinstown, are no longer in action. On a range of hills, situated about midway between the bases of Laurel hill and Chesnut ridge, north of Ligonier, a valuable seam of coal usually nearly seven feet in thickness has been opened in many places, and may be extensively traced; its position in the strata is evidently higher than the seams commonly met with, near the bottom of the series, which measure respectively about three, four and five feet. As it produces coal of a superior quality, the thinner beds are in this neighborhood almost wholly neglected. It follows nearly the summit of the ridge, which ranges along the centre of the valley from Ligonier to Fairfield, to within almost three miles of the Conemaugh. Beyond this point, the large bed is no longer to be met with, the denudation of the upper strata between this and the valley of the river, having left only the lowest portions of the coal series.

A valuable iron ore, belonging to the lowest strata of the coal measures, occurs east of Fairfield, on the western slope of Laurel hill, and has long been worked at Ross furnace in the neighborhood. A little below the thick upper coal seam, which lies between Ligonier and Fairfield, there lies a very useful bed of *limestone*, varying in thickness from three to four and a half feet. It is much less impure than that which generally occurs between the coal beds in this region, and therefore yields a better and whiter lime. Near Lockport, and at other places along the deep valley of the Conemaugh, the lower seams of coal are exposed, and if an extensive demand for coal were ever to arise, they would offer great facilities for mining operations. Extending our explorations northward, along the middle of the valley, we find ourselves again above the lower coal seams, in the neighborhood of Armagh, but they rise to the surface and finally crop out and disappear, as we draw near to the base of either of the ridges which bound the basin. This remark holds good as far north as the tributaries of Yellow and Two Lick creeks, the channels of which, lying in deeply denuded ravines, the lower coal seams are frequently exposed along their banks.

This brings us to the northern termination of Chesnut ridge, which grows very irregular and depressed near Yellow creek. North of the turnpike, between Ebensburg and Indiana, neither the ridge nor its anticlinal axis are any longer perceptible. No valuable beds of coal occur near the town of Indiana, which lies too high for the lower seams, which are exposed in the ravines of Two Lick and Yellow creeks, from four to six miles east and south-east of the town. On Yellow creek near the north-west foot of Chesnut ridge, in the slate above a neglected coal drift, there was found a deposite of iron ore, which would justify more careful examination by digging, being only partially exposed in the bed of a little stream. About five miles northward from Indiana, on a branch of Crooked creek, we find a seam of coal, the position of which in the strata is certainly higher than that of the seams on Yellow and Two Lick creeks. Its thickness is sometimes stated to be seven and a half feet, though it yields only about six and a half feet of coal, the seam being separated into two portions by a band of slate thirteen inches thick, the lower mass of coal being four feet, and the upper two and a half in thickness. Northward towards Mahoning creek, the country is high and rugged, the population more sparse, and the impediments to a minute exploration very considerable. Arriving at Mahoning creek, the seams of coal again appear adjacent to the stream. At Mr. Bell's, north of the Big Mahoning creek and about a mile north of the Jefferson county line, in a position nearly three hundred feet above the level of the stream, a partial excavation of a seam of coal has been made, in a bed which is possibly the same as that alluded to on Crooked creek. At this place, however, the dividing slate is three feet thick, the upper mass of coal being three feet in thickness, and the underlying one buried at the time under water, by imperfect drainage of the mine, was stated to be at least four feet. Between twenty and thirty feet above this coal bed there exists a stratum of limestone, the thickness of which has not yet been ascertained. The lower seams in Mahoning creek are from three to five in thickness, and yield coal of good quality.

In the neighborhood of Punxatawney, there also occurs a seam of coal which has seven feet of thickness.

The details above presented, will serve to show a remarkable regularity in the position of both the coal and the iron ores throughout, indeed, the whole broad belt of country embraced between the Allegheny mountain and the Chesnut ridge, and from the southern line of the State to the counties of Clearfield and Jefferson. Of the coal, there would appear to be at least three seams of moderate dimensions occurring in the lower part of the series; and at a considerable elevation above these, a bed of considerable size and usually of superior quality. To know which of these we are likely to encounter in any given neighborhood, it is chiefly necessary to attend to the direction in which the rocks incline, and to the relative elevation of the place, compared with some one of the strata adopted as a Geological basis. The more usual positions of the iron ore have been already referred to. It is easy to perceive that from the measurements already executed, and from others to be hereafter undertaken, with a view to exhibit as exactly as possible, the relative situation of the several seams of coal, beds of limestone, and the layers of iron ore, which expand widely under the surface of these basins, the explorations of individuals will be greatly facilitated. It is for the purpose of making the details, which I wish to offer in my final report upon these less known districts of our State as precise and ample as practicable, that I propose to continue to some extent, the investigation of the districts above described, and to place hereafter in some of the wilderness portions of the region, north-west of the Allegheny mountains, a part of the corps supplied with a tent or tents, and with instruments for measuring and with tools for exposing the strata, to the extent at least, which is necessary to enable us to recognize and trace the mineral deposites.

It may be useful to those who are exploring some of the mountainous tracts which lie within the enormous coal field above delineated, and serve to guard them against illusions, if I briefly describe the character and aspect of the three formations which are situated next beneath the coal measures, and which therefore frequently occur in the same tracts of country. Next below the sandstones and shales immediately associated with the seams of coal, we have a formation comprising coarse white and yellowish grey sandstones, occasionally imbedding thin layers of dark carbonaceous shale, and usually containing in its uppermost portion, a heavy stratum of coarse white quartzose conglomerate, the pebbles of which are generally rounded. This last rock, where it exists in the formation, is an admirable and well known guide to the position of the coal, the lowest seam of which will be found most commonly, though not invariably, within one hundred feet perpendicularly above it. But in many districts, not only in the interior of the coal fields, but along the Allegheny mountain, the formation is destitute of this distinguishing stratum, and in such places the knowledge of some other land mark, by which the explorer may at any spot ascertain his position in reference to the rest of the rocks, and especially to the coal, becomes of the highest practical value. Such a land mark is to be found, at least throughout a very wide extent of country, on the south-eastern border of the coal field, but particularly towards the southern side of the State, in the highly characteristic and easily recognized stratum of red shale, which constitutes formation XI, of our series. Fortunately, this stratum is present in many situations where the conglomerate, the distinctive bed of the next overlying formation, is wholly wanting. The neighborhood of Farrandsville, on the West Branch of the Susquehanna, suggests itself as an instance. Here the coal is confined to the summits of the loftiest hills in the vicinity, within about one hundred and fifty feet of whose tops we encounter, though much diminished in thickness, the well marked material of formation XI, the total depth of the stratum being only about twenty-four feet. But between its upper surfaee and the bottom of the lowest of the coal seams, the distance is not more than eighty-two feet, and it is within this space that the whole of formation XII, as far as it is developed in this neighborhood, is comprised. Occurring as a fine-grained white sandstone, and being entirely destitute of any layers containing pebbles, it has been frequently confounded, not only here but elsewhere in the State, with the true coal measures that rest above it. The thick series of sandstones and shales which compose formation X, and form the entire mass of these hills down to the level of the Susquehanna, has been also considered as belonging to the proper coal bearing strata. This mistake, which has proved a very pernicious error, has arisen from overlooking the well traced line of separation which nature has drawn between the strata, affording us an unerring guide, in the beds of the red shale formation. This red shale mass, formation XI, though a conspicuous and very thick stratum, where it encircles the mountain ridges which enclose the anthracite coal measures, thins away to extremely diminished size, when we extend our observations as far northward as Lycoming county. From numerous measurements made in a former year and presented in my last annual report, it exhibits perhaps more strikingly, than any other rock of our secondary series, a rapid abatement in thickness, as we pursue it to the north-west. But while it augments to the south-east, it likewise expands, though very gradually, as we trace it south-westward, acquiring as it ranges in that direction, a new and highly valuable layer, consisting of a very thick band of pure limestone, inserted near the bottom of the mass of red shale. The increased thickness of the whole formation and the position of the included stratum of limestone, may be seen in the striking exhibition of the rocks, afforded by the Conemaugh and the cuttings of the Allegheny Portage rail road, where the latter crosses that stream by an interesting viaduct. Still further to the south, the formation contains a bed of calcareous sandstone, and is considerably developed in the Little Allegheny, the Savage, the Great Allegheny, and the Negro mountains, also in Laurel hill and Chesnut ridge, (here erroneously called the Laurel hill.) This calcareous sandstone, which in some places approaches closely to a limestone, is extensively employed as a road stone for McAdamising the National road, and to a partial extent other turnpikes which lie convenient to its outcrop. For this it is admirably adapted. In thickness it varies from thirty to sixty feet. Near the National road it is reddish in the lower layers, and of a light bluish grey in the upper, but as we trace it northward, the reddish bands disappear. In many places in the southern part of the State, this highly calcareous sandstone is overlaid by a limestone a few feet thick, which is an extension apparently of that above referred to, as seen on the Conemaugh. This limestone is converted into lime, in considerable quantity, at Peck's and Ringer's, in Addison township, in Somerset county, the lime being much prized, as it greatly exceeds in purity and whiteness, any which is procured from the limestone of the coal measures. Certain bands of this limestone and of the shale contiguous to it, are exceedingly fossiliferous, and as formation XI, to which the rock belongs, presents in scarcely any other district of the State, sufficiently distinct fossil remains, to enable us to institute a comparison between this and the other formations, as to the circumstances under which their strata were deposited, these characteristic relics, are invested with considerable scientific interest.

Having given a general description of formations XII and XI, it remains for me to allude to the formation X. This stratum consists of a thick mass of white, grey and buff colored sandstones, with interstratified beds of brown, dark bluish and olive colored slates, among which are occasional bands of dark carbonaceous slate, not unfrequently appealed to as an evidence that the whole is a series of coal measures. This error, so prejudicial by inducing a search for coal in this formation, is apt to receive confirmation in the minds of those who study the mere analogies in the external aspects of the rocks, and neglect the more certain guide afforded by the relative positions of the several strata, inasmuch as they frequently find in some parts of the mass, the impressions of vegetation, or even thin sheets of an inferior species of coal of very limited extent and thickness, such as we often see among the true coal-bearing slates and sandstones. The thickness of formation X is very considerable, being usually several hundred feet. This circumstance, in conjunction with the relative hardness of its strata, contrasted with formations XI and VIII, which adjoin it, has caused it to resist the floods that scooped out the valleys in the softer rocks, and to raise into bold and conspicuous ridges. In consequence of this character, the formation before us constitutes the true border of the great bituminous coal field; at least every where along its south-eastern margin, capping the escarpment of the Allegheny mountain in almost every part of its range, from Maryland to the North Branch. From the same cause, it is exposed in all the axes of elevation which sub divide the great coal field, in the southern part of the State. Thus it occupies the broad summit of the Negro mountain, near the Maryland line, and forms the top and no inconsiderable portion of the sides of both the Laurel hill and Chesnut ridge, throughout nearly their entire length. Where these ridges decline towards their extremities, formation X becomes buried under formation XI and formation XII, which there fold over their summits. Where those mountains retain their full height, the two latter strata usually rest upon their flanks. Formation XI, usually containing in these situations valuable deposites of iron ore, at present in much request at the neighboring furnaces, this structure of the ridges just mentioned, imparts much practical importance to their Geology. The systematic investigation of that valuable formation already commenced, will be therefore pursued with as much minuteness as the organization of the Geological survey will authorize.

SECTION 3.

Of the operations of the survey in the fifth district, embracing the country west of Chesnut ridge and the Allegheny river.

Having in the foregoing descriptions, presented as concisely as practicable, a portion of the observations made in the exploration of the country between the base of the Allegheny mountain and the summit of Chesnut ridge, and having reserved for my final report the chief body of the more minute and local details, together with the results of instrumental measurements, all of which require to be ultimately accompanied by numerous drawings and a Geological map of the region, before they can be adequately understood, or their practicable importance fully appreciated; I shall in the next place offer a similar general account of the Geological structure and resources of those sections of the State which we have explored, lying west of Chesnut ridge, and also between the Allegheny river and the Ohio State line.

Considering the anticlinal axis of Chesnut ridge, and a range of elevated strata nearly in its north-east prolongation, as the true boundary of the main or north-eastern basin of the whole bituminous coal field of the State, and the low chain of hills capped by the sandstone and conglomerate of formation XII, passing through Mercer, Crawford and Warren counties, as its other margin, (the minor undulations within these limits requiring to be neglected, in a comprehensive view,) we shall find proofs of a remarkable degree of uniformity in the strata and their contents over this extensive region, implying a singularly extensive range in many of the principal beds of the formation. The influence of this feature in the Geology, on the early and full developement of the economical resources of the western and north-western counties, it would be difficult to overrate, for the data derived in any one neighborhood from judiciously planned and conducted measurements and observations, become of exceedingly wide application, in leading us to a knowledge of the state of things elsewhere; and if these measurements can be made sufficiently numerous, an amount of accurate knowledge will be furnished, capable in such a region of imparting a high degree of certainty and success to the undertakings of miners and others, who aim at unfolding its mineral wealth, to supply the wants, or add to the comforts of the community.

In presenting a brief description of this western coal basin, I shall commence on the side next the anticlinal axis of Chesnut ridge, and make mention of the various strata in the ascending order, which leads us to the beds of the coal formation, as they cap the surface in the interior of Greene county, and therefore to the uppermost of that vast series of deposites, which I have termed the lower secondary formations of Pennsylvania.

The same order will be observed in speaking of the country included between the Allegheny river and the Ohio State line.

SANDSTONES AND SHALES OF FORMATION X.

The lowest rock which presents itself to our notice in obedience to this plan, is the thick sandstone, formation X, which bounds the basin, ranging in a belt along the summit of Chesnut ridge, where it shows itself in many places, folding with opposite but gentle dips, over the anticlinal axis of that mountain. Where the National road crosses this ridge, we find it in the form of a hard, white, fine-grained sandstone, with a somewhat glazed surface, often thin-bedded in its structure, and much traversed by fissures and irregular joints. It is of considerable thickness, and dips to the west twenty-five degrees north, at an angle of twenty-five degrees. Beneath it there is a thick mass of alternating beds of slaty sandstone, and shale or slate, the former in layers of from one to thirty feet in thickness, being hard, fine-grained and of a grey color; the latter black and yellow, and sometimes of a feruginous brown color, irregularly laminated, and readily crumbling when exposed to the atmosphere.

On the Loyalhanna, similar sandstones are met with, while on the Conemaugh, above Blairsville, the observer will notice in the same relative situation, a number of alterations of white and grey sandstones, separated by shales.

FOSSILIFEROUS LIMESTONE OF FORMATION XI.

This rock, interposed between the previous sandstones and the overlying red shale to which it belongs, is the best marked, most peculiar and interesting rock of the series composing this mountain range. It can be traced from the Conemaugh to the southern State line, and is found dipping both east and west, or on both sides of the anticlinal axis. It is a siliceous limestone, or a limestone containing a small quantity of pure and well rounded grains of sand, is of fine texture, and of a light blue color, though sometimes its tint is yellowish green. On the National road it is found on the first ridge, and also on the main mountain, in the former case, dipping west fifteen degrees north, at an angle of twenty-five degrees. It lies in layers of from one to ten feet or more in thickness, separated by bands of a calcareous shale. The upper part is remarkably full of fossils, as is also the intervening shale. On the Susquehanna, there are two beds or layers exposed, separated by a thick bed of red and yellow shale, containing a few bands of limestone. The lower bed is a most singular rock, of a light blue color, very hard, and breaks with a semi-conchoidal fracture. It dips nearly due westward, at an angle of ten degrees. Occasionally the yellow color predominates, giving the rock the exact appearance of some varieties of serpentine. When exposed to the water it decomposes, the calcareous matter being washed away, leaving a porous and siliceous crust of an inch or two in thickness, which will not effervesce. This bed measures thirty feet in thickness, being a nearly solid rock, without a seam, the upper one is of a darker color, harder and more fossiliferous, and four feet in thickness. At other points on Chesnut ridge, this rock is met with having a considerable thickness, but no opportunity was there afforded for accurately measuring it.

On the Conemaugh, this stratum is exposed on both sides of the axis, dipping both east and west; it is accompanied with shale of a bright purple color, and appears to be very thick. There is reason to believe that small quantities of *lead* and *zinc* ore may be detected in the lower beds of this deposite, particularly on Chesnut ridge, where it seems to have reached its greatest developement. Regarding it and the accompanying red and variegated shales, as belonging to formation XI, underlying the western coal measures, the whole group will be seen to be much thicker here than further north-eastward in the State, especially along the Allegheny mountain, while its features are more characteristic. The dark blue bed of limestone, which is full of fossils, usually affords an excellent lime.

RED SHALE OF FORMATION XI.

Overlying the limestone and surmounted in its turn by the sandstone and conglomerate beds of formation XII, occur the beds of variegated shale belonging to formation XI, red, black and yellow, which are much exposed in various places by diggings made in search of ore. At Cool Spring furnace, there are found two thin veins of coal, about one foot thick, beneath the conglomerate. The first dips at an angle of thirty-two degrees, and is imbedded in the shale. Beneath it is a bed of blue ore, a proto-carbonate of iron in three layers, composed of irregular nodules from eight to fifteen inches in diameter. It is not probable that any large deposites of coal will be found in this stratum of shale, inasmuch as the conglomerate beds of formation XII appear, with only few exceptions, to underlie the lowermost workable coal bed in all the coal basins of our state—but as a depository of ore it merits close investigation. This stratum is well exposed on the Loyalhanna near Youngstown, and also on the Conemaugh above Blairsville. At the former place its beds are red and blue, well laminated and compact, and dip at an angle of ten degrees, nearly due west. The thickness here from approximate measurements, that were made, must be nearly ninety feet. At the latter place it is much thinner, and of a prevailing purple or red color.

SANDSTONE AND CONGLOMERATE OF FORMATION XII.

Running parallel with the preceding and resting upon it, we find, on the western flank of the Chesnut ridge, an important and conspicuous stratum, forming the true margin of all our coal basins. Here it dips towards the west, under the coal measures at the base of the Chesnut ridge. It is a true conglomerate, particularly in the lower part. The pebbles are of white quartz, sometimes disposed in bands, but at other times forming a very coarse conglomerate, excessively hard, which has a glazed appearance. On the Chesnut ridge, opposite to Uniontown, it is well exposed, its outcrop forming a ledge about thirty feet in height. It dips at an angle of thirty-five degrees, in a direction west, twenty-five degrees north. It must be recollected that only the lower part of this stratum is a true conglomerate, and as we follow it north, this portion of the stratum seems to be less perfectly developed. On the Loyalhanna, where the formation is easily recognized by its position in regard to the fossiliferous limestone, it shows little of the conglomerate character, being a coarse white sandstone. At Mount Pleasant it was not seen in place. Pursuing it towards the south-west, it appears to increase in thickness, until we cross the Virginia line.

FORMATION XIII—COAL MEASURES.

No. I. Colored shales with Coal six feet thick and Iron ore.

At the bottom of the true coal measures, the first distinctly marked sub-division of the strata, is a thick bed of shale. It is generally soft and usually highly colored, being red, black and yellow in various shades. It contains both iron ore and coal. At Cool Spring furnace, ore of good quality has been obtained from it, and Etna furnace, one mile east of Connellsville, is also supplied with ore from the same stratum, which has been worked for twenty years, and gives every indication of containing an almost inexhaustible supply.

At the former place a seam of coal has been opened at several points, and is estimated to be about six feet in thickness. It appears to be of good quality, and lies in the lower part of this shale stratum. It is accompanied by bands of ore. Near Youngmanstown, two and a half miles north of the Loyalhanna, a seam of coal has been opened on the property of W. Johnston, Esq., which, from several features about it, is probably the same with the one above described; if not, it occupies very nearly the same position. It is near the summit of the first or westernmost ridge of the mountain, is six feet thick, and is probably accompanied by ore, although no excavations have been made for that mineral.

This stratum, from its well marked position and valuable contents, is worthy of a detailed examination throughout its whole extent, and in the future operations of the survey, will receive its due proportion of research.

No. II. WHITE SANDSTONE.

Along the summit of the western ridge of the mountain, called the Chesnut ridge, there can be traced a thick stratum of sandstone, dipping with a regular inclination to the west, twenty-five degrees north. The outcrop of this rock forms, in many places, a steep ledge thirty feet in height. It is a solid and generally fine-grained sandstone, admits of being readily dressed, and splits into well-shaped prismatic blocks. Sometimes it crumbles, on exposure, into a beautiful white sand. The general color of the stratum is yellowish white; it is also seen brown, red, or with spots of a peculiar rosy tinge. The lines indicating the laminæ of deposition, are generally very evident, and the lower portions are sometimes a conglomerate in thin and irregular bands. These bands are composed of white quartz pebbles of small size. This stratum, apart from its thickness and extent, is important, as pointing to the principal position of the iron ore so abundantly distributed along this ridge, and which lies chiefly beneath it and above the main conglomerate or formation XII. It is well exposed on Chesnut ridge, opposite to Uniontown; also at other points in the same chain, as at the gap of the Youghiogheny and opposite Mount Pleasant, and on the Loyalhanna, where it abounds in impressions of lepidodendra, sigillaria, and other plants common in the coal measures.

No. III. SHALE—COAL THREE FEET THICK—IRON ORE.

Overlying the white sandstone, there rests a heavy bed of shale of the variegated appearance, quite usual in the lower shales of this section of the basin, whose thickness, though obviously considerable, was not determined, through want of a favorable place for making the measurement. This shale, like the other similar beds of the mountain, contains coal and ore, but the principal imbedding stratum of the latter mineral, is the shale (No. I,) already mentioned, between the white sandstone ledge and the conglomerate. At Cool Spring furnace, three and a half miles north-east of Uniontown, a coal seam about three feet thick shows itself in this stratum. This has not been mined, but iron ore of good quality has been obtained from the yellow and black shale above it.

No. IV. SANDSTONE.

This stratum in its upper part consists of layers of sandstone separated by shale, which is yellow and black, very soft and full of vegetable impressions. The layers of sandstone are hard and fine-grained, usually from three to six inches in thickness, and gradually become more numerous and close together, as we pass towards the bottom of the mass, until a compact rock presents itself. These thin beds are often broken and contorted in a singular manner.

No. V. SHALE.

Ascending, we pass from the upper layers of the preceding stratum, by a gradual transition into a bed of shale, resembling the shales of the open country, west of the base of the mountain. It is soft and imperfectly laminated, and like the other shales described, of several colors, being brown, black and yellow. Thickness, one hundred feet.

No. VI. SANDSTONE, 100 FEET THICK.

Surmounting the shale just mentioned, in the part of the mountain that lies to the south-west of the Chesnut ridge, (called Laurel hill on the map,) and which is here much elevated, and contains the strata better developed than the north-eastern portion of the ridge, we find a sandstone of some thickness. The rock in the upper part is coarse and brown, that in the lower part occurs in layers very hard and tolerably fine-grained. The thickness of this rock cannot be less than two hundred feet. It was identified only on the south-western section of the Chesnut ridge, where it is inclined at an angle of twenty degrees, dipping nearly due west.

No. VII. SHALE WITH LAYERS OF SANDSTONE—COAL.

The next sub-division of the series is a bed of shale, with layers of sandstone. It appears to be of considerable thickness. These layers, from one to four inches in thickness, consist of a yellow fine-grained sandstone. The shale is yellow and black, constituting the principal part of the bed as far as hitherto determined. At several points along the base of the mountain, there are decided indications of the existence of beds of coal in this stratum; indeed, in a few places these have been opened. They are unquestionably seams that are situated below the Pittsburg series, rising and cropping out along this line. This part of the country is still so covered with forest, and the excavations are so limited, that it is impossible to see the accompanying strata, and consequently to determine the precise situation of these seams; but there is at present good reason to believe that two of them are contained in this bed of shale and sandstone.

On the farm of Mr. Woods, in Union township, Fayette county, at the base of the mountain, a coal seam is found dipping westward at an angle of eighteen degrees, in apparently the above mentioned sandstone. It is about four feet thick, but the accompanying strata are not discernable, except where the following section is exposed:

Soil,	2 feet.
Shale, yellow,	4 "
Coal, impure,	1 "
Shale, blue and friable,	2 "
Coal compact,	4 "

About one hundred yards west of this exposure, on the same ridge, we encounter evidences of another coal seam, which has not yet been opened. About one mile south of this place, a drift has been made into a bed of coal, which we have good grounds for believing is the same as the one here mentioned. This place is just at the foot of the mountain, and on the east side of a low ridge, which shows shale and slaty sandstone dipping west, and overlying the coal. There are also indications of another vein, observing the same distance above the first, as exists between the small seam noticed in the section and its companion.

About one-fourth of a mile west, the *Pittsburg seam* presents itself, exhibiting a noble bed of coal, nine feet in thickness.

In Derry township, Westmoreland county, about three miles north of Youngstown, a seam of coal has been opened on the farm of —— Knoll, presenting features which give us reason to believe it to be a continuation of the bed above referred to, as belonging to the present sub-division of the strata. It can be traced for some distance on a low ridge, about one mile from the mountain, and is worked in several drifts. It measures five feet in thickness, yields coal of good quality, and exhibits just over it, layers of shale and slaty sandstone, though imperfectly exposed.

About six miles west of Mount Pleasant, in Westmoreland county, there are numerous salt works on the Big Sewickly creek, which are supplied with fuel from a coal seam, whose presence in this position can only be accounted for by supposing it to be one of the inferior beds thrown up in the line of an anticlinal axis, which passes in this vicinity. This bed is five feet thick, with brown shale above and below it, and is worked for the use of the salt wells and steam mills adjacent. Salt water has been found here at the depth of one hundred and thirty feet. Both to the east and the west, a thicker bed, being the same with the main Pittsburg seam, is extensively mined.

The coal seam, which, for the sake of precision, I denominate the Pittsburg seam, is found about three miles west of the creek, and two and a half miles east of it.

At Middletown, in Fayette county, near the line of the anticlinal axis before mentioned, there is exposed a bed of coal three feet in thickness, at an elevation of about thirty feet above the Red Stone creek. Overlying it, are brown and black shales and a slaty sandstone. Judging from a hasty examination, this bed must lie beneath the Pittsburg strata, and probably be identical with the one above described.

No. VIII. Sandstone.

On the western slope of the hills which we first meet in the ascent of the Chesnut ridge, and which form the first bench or terrace on the flank of the mountain, the only rock seen in place, is a slaty sandstone of a brown color. It is hard and coarse-grained, occurs in layers from six to eight inches thick, which increase in number and thickness towards the lower part of the stratum. It is very indistinctly exposed, being covered with soil, vegetation and the debris from the more elevated rocks of the mountain. This stratum was principally noticed at Uniontown; but in other situations, the rock immediately at the base of the mountain, is so similar to it in many respects, that it is not practicable to distinguish them.

Our principal object in the explorations during the past season, being to ascertain the nature and contents of the strata which compose the valley of the Monongahela, as far eastward as the base of Chesnut ridge, our examinations of the mountain were necessarily very general. From a deficiency of time, which another season will remedy, we were only enabled to investigate minutely a few points, namely: opposite Uniontown, on the National road, at the gap of the Youghiogheny, opposite Mount Pleasant, on the Loyalhanna, near Youngmanstown, and on the Conemaugh, above Blairsville.

Along the western base of the ridge, the Pittsburg series rises to the surface, the coal No: seen in place on the Allegheny river, being in many places from half a mile to two miles from the mountain. It is by no means easy, however, to distinguish the other strata associated with it. From the Youghiogheny to the State line in a southwestern direction, there may be seen a depression or narrow valley running along the foot of the mountain. Immediately west of this little basin or valley, there rises, displaying along its eastern slope one or two low steps or terraces, a long anticlinal elevation of considerable breadth but no great height. It can be traced north of the Youghiogheny, but in that direction gradually becomes less distinct. This valley was most probably formed originally by the scooping action of the retreating waters, as they precipitated themselves down the western flank of the mountain, rushing with enormous momentum over the soft shales that so largely compose this lower stratum of the coal measures. Its existence, interesting as a subject for geological speculation, is rendered additionally important by the impediments it offers, in the present state of the surface of the country, to our ascertaining all the strata which lie immediately beneath the great Pittsburg coal seam, and which necessarily reach the surface along this belt of country, at the base of the mountain. The foregoing account of this lower part of the series is, however, tolerably complete, and I entertain a confident hope that the explorations of the next season in the same district will leave nothing of practical or scientific interest connected with these rocks undetermined. By employing the more ample data which we are collecting along the western base of Chesnut ridge, to interpret the stratification of the far less distinctly developed basin that lies along the eastern base of the same mountain, we shall be able to clear up much existing obscurity in our knowledge and add materially to the usefulness of future explorations in that quarter.

PITTSBURG SERIES.

Commencing at the level of the Ohio river at Pittsburg, and embracing in the ascending order all the strata, to the uppermost in the series as far as they have yet been identified.

No. 1. Red and Blue Calcareous Shale.

At Pittsburg we find at the base of the hills which overlook the city, a bed of variegated calcareous shale, of a peculiar mottled appearance, its lower portion reaching down nearly, if not quite to the brink of the Ohio river. This shale we make the first in our enumeration of the strata which compose the valley of the Monongahela. At the mouth of Sawmill run, and at several other places in that vicinity, a bed of sandstone is seen just rising above the water level, probably the upper part of a thick deposite; but as it has not yet been observed in other places, and no opportunity for its further examination has been thus far afforded, it is omitted for the present, and considered as belonging to the strata beneath the present series. The shale above mentioned is a bed of considerable thickness; it consists of two varieties, one blue and the other a bright purple or red, irregularly intermixed in spots, blotches and bands. The blue variety lies sometimes in continuous layers. It is soft and calcareous, sometimes without any regular cleavage, and exists throughout as a rather homogeneous mass, very friable and easily crumbled by the weather. Dispersed through it, are numerous calcareo-ferruginous concretions, lying in irregular layers, and occasionally so abundant as to constitute a considerable part of the whole bed. They are of all sizes, more or less ferruginous and excessively hard.—Some minute fossils have been detected in this stratum, but it is generally not fossiliferous. The quantity of calcareous matter diffused through the shale is such, in fact, as to warrant our considering it an impure *marl*. From Pittsburg it may be traced along the western bank of the Allegheny river to some distance above Sharpsburg, rising as it extends northward in conformity with the general slight south-western dip of the strata. On Thompson's run, a branch of Turtle creek, fourteen miles east of Pittsburg, it is met with at nearly the same elevation as at that city, forming the base of the hills. Being at the bottom of the series as hereabouts exposed, it is only within confined limits, restricted to the lowest parts of the central district of the coal basin, that this stratum is exhibited. Back from the rivers it conceals itself beneath the hills, and must finally crop out upon the surface (if it does not thin away) towards both the south-eastern and northern sides of the basin, where we hope that extended researches will identify it and trace its position.

No. II. Coal.

Resting on the above, is a thin seam of coal, varying in its thickness from six to eighteen inches, and of good quality, and though a narrow band, ranging over a considerable, perhaps even an extensive area of country. It is hard, black and brilliant. It is well displayed in contact with the preceding stratum at the base of the hills in the immediate vicinity of Pittsburg, and was detected by us also in Indiana township, Allegheny county, and in Franklin township, Westmoreland county. It probably crops out towards the north and east, with the other members of the series, but its thinness renders it difficult to trace it by any indications of its own on the surface. One foot is about its average thickness.

No. III. Limestone.

This is the highest fossiliferous limestone met with, in the Monongahela valley. It is a dark grey or black limestone; when first exposed is extremely hard, effervesces freely when treated with an acid, and is remarkable for the abundance, though not the variety of the fossils diffused through it. These are principally bivalves, species of productus, leptena, terebratula, &c. Joints of encrini are also very abundant, from one-sixteenth to one-half an inch in diameter, the column being composed of crystallized carbonate of lime, which has a brilliant appearance when freshly broken. Another very abundant and characteristic fossil is a species of orthecera, from one-half to two inches in size, often abundant on the surface of the rock. Ammonites have also been found in it. When exposed near the base of the hill, this stratum forms a shelf above the small coal bed; it is of a brownish grey color, and outward slaty structure. If judiciously selected it will make a good lime, and has been used for the purpose on the Mechanics' and Farmers' turnpike at Pittsburg. In company with the preceding strata, it rises to the north along the margin of the Allegheny river. It has been detected by us in Indiana, Wilkins and Versailles townships, Allegheny county, and in

Washington and Unity townships, Westmoreland county, and on the Kiskiminetas, below Saltsburg. Thickness about two feet.

No. IV. OLIVE SLATE AND BUFF COLORED SHALE.

The next stratum ascending, is a heavy deposite, consisting of shale, passing into slate, with sandstone layers. The lower portion is a soft shale of a drab or yellowish color, regularly laminated, and decomposing into a stiff clay. Nodules or concretions of compact, fine-grained and tolerable pure limestone are dispersed through it. It passes into a heavy slate, of a blue, yellow and black color. It is slightly micaceous, contains a good deal of sand, and splits into plates, somewhat resembling roofing slate. Upon this, in some places, there is a thick bed of slaty sandstone, passing gradually into a smooth slate. The sandstone layers are sometimes very compact and heavy, at others separated by bands of shale. The dark colored portions of the stratum, are generally fine-grained, have a ready cleavage, and contain impressions of plants. Plates may be obtained two feet square, beautifully marked with these remains of an ancient vegetation. These are not found in the hard siliceous upper layers. The whole mass may sometimes be observed, divided in a vertical direction by joints, which separate it into prismatic blocks and impart a picturesque appearance to the exposed portions. Layers of calcareo-ferruginous concretions are found running parallel to the cleavage. They are generally round and rough or knotty on the surface, and from two to four inches in diameter.

The upper part of this bed, immediately beneath the overlying stratum, differs frequently in appearance from the rest. It is much softer, red or yellow in color, and slightly ferruginous. The hard siliceous portions afford an abundant supply of good flagstones. The dark black bands have been mistaken for the soft shale accompanying the coal.

This member of the series may be traced generally along the water courses throughout Allegheny county, and is exposed in Unity and Franklin townships, Westmoreland county, and Connelsville township, Fayette county.

Thickness by estimation—one hundred feet.

No. V. Grey Sandstone—Building Stone.

Upon the above, there rests a valuable and important deposite of sandstone. The lower portion is very solid and compact, affording an excellent material for building and differing from the upper, which is generally too slaty and broken to be used for this purpose. The prevailing color is a light grey, with a yellowish tinge; in other places it is brown and brownish green. It varies in composition as much as in color, but generally admits of being easily dressed, and of being readily split into prismatic blocks. Some portions are remarkably micaceous, in others the mica is entirely wanting. Occasionally, it is not fit for masonry, being too friable, and crumbling too freely on exposure to the atmosphere, in consequence, chiefly, of its containing in these cases, a considerable proportion of clay. In this rock, the lines of deposition are very manifest, forming beautiful curves and accurately representing the eddying currents, by which the fine sand was originally deposited. These are most evident, where a brown layer interposes itself in the lighter colored rock.—Imbedded in the lower parts of the mass, are great quantities of pebbles, which differ in color and composition from the material of the surrounding sandstone; they consist, generally, of a drab or a bluish colored clay of a fine texture, and contain minute specks of mica; they are from one to fifteen inches in diameter, but always rounded, and apparently water worn. The question of their origin suggests some interesting enquiries, but I shall for the present waive all matters of mere hypothesis.

The lower part of the stratum contains also thin seams of vegetable remains. These fill the joinings of the layers, and are composed of black carbonized matter, which, in some instances, assume the condition of a pure coal. They are slaty, friable, and emit a bituminous odor, when freshly broken. These impressions are generally so interlaced and compact together, that it is difficult to distinguish their forms; now and then, however, distinct figures are traceable from six to eight inches broad, and also curved stems of considerable thickness.

In many situations, this rock is soft, crumbly and granular, consisting of rounded grains of sand, of a dark green and sometimes a brown color, passing into a ferruginous reddish tint. This change of color depends upon the quantity of iron present in the rock, and the stage of decomposition to which it has arrived. The grains are of pure white quartz, evidently water-worn and united by a calcareous cement, particularly in the green and brown varieties. In the former, some minute fossil univalve shells have been detected.

This rock is sometimes met with, in a state of complete decomposition in the form of a coarse sand. Certain layers are yellow, others bright red, with intervening layers of gray sandstone, which, by their containing but little iron, have resisted decomposition. In these cases, the thin flakes of the vegetable remains have been replaced by layers of black clay and sand. The rock in this state is too friable to admit of being transported. The upper part of the main stratum into which the preceding passes, is generally very schistose, with irregular laminations, and presents a broken, shattered appearance. It is sometimes very full of nodules, which are chiefly concretions of an impure iron ore. This stratum affords an abundant supply of building stone to the city of Pittsburg. The sandstone employed in the construction of the new Court-house, the Western Penitentiary, and other public buildings, and also some private edifices, belongs to this member of the series. It is quarried in many places on the Monongahela, along whose banks it can readily be traced, until it sinks below the water level of the country, along with the other strata situated below the Pittsburg coal. Medium thickness seventy feet.

No. VI. SHALE.

This is a bed of red and marly shale, internally blue and mottled, resting on the schistose part of the preceding stratum, and forming in the hill sides a well-defined belt of a bright red or purple color. It is in general imperfectly laminated, slightly calcareous and contains traces of fossil shells. It is not exposed on the hills immediately around Pittsburg, but may be observed on the level, or slightly undulating flat upon which East Liberty is situated. It extends widely through Allegheny county. The thickness averages twelve feet.

No. VII. SHALE AND SLATY SANDSTONE.

The next, in order, is a thin and inconspicuous bed, yet sufficiently different from the accompanying strata to claim for it a separate recognition. It consists of blue or yellowish green slate, marked with ferruginous discolorations, and contains layers of sandstone. When these predominate, it is a coarse slaty sandstone. Ten feet.

No. VIII. LIMESTONE.

This is the first or lowest of the non-fossiliferous beds of limestone beneath the Pittsburg coal seam. It is a well-defined stratum consisting of a hard, yellowish or buff colored limestone, jointed into square blocks. It effervesces freely, gives out an argillaceous odor, and is marked with transparent specks of crystallized carbonate of lime. It probably contains too much oxide of iron and argillaceous matter to yield a good lime. For weight and hardness it is quite remarkable. Although frequently exposed along the hill sides, it is not easy to trace this stratum, as it is very apt to be covered up by the matter from the overlying shales. Thickness three feet.

No. IX. RED AND BLUE SHALE.

Reposing in immediate contact with the preceding, we observe a bed of red and blue shale, distinguished by its want of tenacity, its bright colors and smooth cleavage. The red and blue portions are irregularly intermixed. This is one of the colored shales which give the red and variegated appearance to the lower part of this series and may be met with on the sides of the hills and ravines, throughout Allegheny and the northern part of Westmoreland counties. Around East Liberty, this and the next stratum are found on the surface of the remarkable flat on which that suburb is situated, in many places decomposed and forming a red soil. Thickness four feet.

No. X. BUFF COLORED SHALE.

Along the escarpement of the hills where the strata have been laid bare by slides or artificial excavations, we meet with a smooth face of compact and well laminated shale of a light yellow and buff color This shale so greatly resembles in appearance some of the other beds, that it can only be identified by its relative position to the accompanying strata. The surface is frequently white from infiltrations of carbonate of lime, and in other places is tinged brown with ferruginous stains. Thickness eighteen feet.

No. XI. YELLOW AND PURPLE SHALE.

We have next a bed of variegated shale extending to the bottom of the next limestone. The lower part is frequently of a dark purple color, and is very soft and not well laminated. The prevailing color is yellow. It is frequently exposed on the sides of the runs and water courses. Calcareous nodules are scattered through it, sometimes constituting the largest portion of the stratum. Thickness ten feet.

No. XII. LIMESTONE.

Upon the preceding, is a thin bed of limestone, resembling No. VIII in appearance and composition. Blocks of it are frequently scattered along the base of the hills, having fallen down from the washing away of the underlying bed of shale. Thickness two feet.

No. XIII. RED AND YELLOW SHALE.

The next stratum is a bed of red and yellow shale. It varies much in composition, but preserves its variegated character. It is soft and friable and contains a few calcareous nodules. Thickness twelve feet.

No. XIV. LIMESTONE.

Over this rests a conspicuous and widely expanded bed of limestone of moderate thickness; owing to the presence of the oxide of iron, it is yellow on the surface, though internally its color is dark blue. It breaks off in square or oblong blocks, which are hard and heavy. Portions of it might, perhaps, receive a good polish, and experiments to ascertain this point will be made. By the decomposition of the underlying shales, it is often found tumbled down at the base of the high hills which enclose the Monongahela and Youghiogheny rivers, along whose shores its fragments are frequently abundant. Thickness from three to five feet.

No. XV. SHALE AND SANDSTONE.

Surmounting the last limestone, there occurs a thick and important deposite of shale and sandstone somewhat variable as to its composition, which extends up to the next bed of limestone or that which underlies the main Pittsburg coal seam. It may in almost all cases be seen where the coal itself is exposed, generally in the character of a grey slate, well laminated with interspersed sandstone layers, varying from a few inches to several feet in thickness, and separated by soft bands of shale. The upper part of this stratum adjacent to the limestone is frequently very soft and friable, abounding in calcareous nodules, irregularly dispersed throughout the mass. Occasionally, but not very often, the sandstone layers increase in number and thickness, with a corresponding diminution of the shales, giving rise to a sandstone sufficiently compact to be employed in building. It is quarried for this purpose in the vicinity of Pittsburg, though more usually its principal useful application is in supplying much excellent flagstone, which it readily affords of large size and very smooth surface. This stratum extends through the valley of the Monongahela, from the foot of Chesnut ridge to the western boundary of the State, obeying the general inclination of the accompanying strata, and exposed in corresponding situations. The sandstone layers very frequently exhibit "ripple marks," disposed with great regularity, showing that the rock was deposited from a rather gentle current and probably in a shallow sea. Impressions of arundinaceous plants are not uncommon. Thickness, by estimation, thirty feet.

No. XVI. LIMESTONE.

Resting on the above, and immediately underlying the Pittsburg coal seam, is a bed of limestone of characteristic appearance and remarkable for the regularity with which it accompanies the coal. It consists of blue and black limestone in layers from six to ten in number, separated by shale. One of these layers is generally found immediately under the coal seam, succeeded by the principal body of the shale, beneath which are the remaining layers of limestone in a close and continuous stratum. These layers are from one to two and a half feet in thickness and vary in their color, which is generally dark blue, though at other times it is a deep black, in which case the rock is ferruginous, and gives out a bituminous odour. When there is a deficiency of calcareous matter, the upper layer adjacent to the coal seam is wanting, and its place is supplied by a layer of excessively hard calcareous nodules called "nigger heads" by the miners, and which are imbedded in the usually intervening shale. In the northern part of the district this shale is of a light yellow and brown color, is slightly calcareous and contains some ferruginous concretions. In the eastern part of the district, along the base of Chesnut ridge, it is distinguished as one principal depository of the valuable iron ore for which that belt of country is deservedly noted. Like many of the other strata of the series, it appears to augment in thickness and particularly in its ferruginous character as we advance south and south-east. It is chiefly along the eastern outcrop of the Pittsburg coal seam, that we are to look for valuable deposites of *iron ore.* Thus, in George and Union townships, in Fayette county, large quantities of admirable ore are obtained from this stratum.

It underlies the coal which is here of increased thickness. The ore is of the variety properly called an argillaceous protocarbonate of iron, distributed in layers throughout the shales. There are three of these layers in close proximity in many places; the first, called the blue stone, is about two feet below the coal and separated from the next, the masses of which are smaller in size, by clay or crumbling shale from one to two feet in thickness. Under this is the third layer or bed, of still smaller nodules, separated from the former by two feet of shale. Ore has been found in this stratum in various neighborhoods.

Instead of the black and crumbling shale dividing the lower layers of limestone, we sometimes witness a layer of coal one foot thick. This is the case at Brownsville and Connellsville. Its true character and composition may be ascertained from a comparison of sections taken near Pittsburg, Canonsburg, Williamsport, Limetown, M'Keesport, Elizabethtown, Brownsville, Connellsville, Blairsville, and other points throughout the district explored. Average thickness of the whole stratum twenty-five feet.

No. XVII. Coal—Pittsburg Seam.

Resting on the great limestone bed, we find the important coal seam, from which the city of Pittsburg and its environs are supplied with this indispensable mineral, and which may, therefore, by way of distinction, be entitled the Pittsburg seam. It is probably the most important and extensively accessible seam of coal in our western coal measures. The examinations of the season have shown that it spreads uninterruptedly over the whole valley of the Monongahela, from the base of the Chesnut ridge to the western boundary of the State, if not to the Ohio river. The critical investigation of this bed and its accompanying ores, is highly interesting, and leads to some curious and striking geological inferences. The uniform disposition of vegetable matter over so extensive a tract of ocean, is in itself a geological fact, richly worthy of consideration, by any intelligent mind, while the regularity with which it maintains its characteristic features, is not less remarkable, or less likely to inspire us with curiosity to know more of the mighty operations of nature, during the earlier conditions of the earth's ever changing surface.

It consists of three parts, first the main breast of coal, and above this a layer of clay, and over this again a bed of coal, forming the roof. The former of these rests upon the limestone, from which it is separated generally by a few inches of blue clay or decomposed shale. It is from five and a half to eight feet in thickness, affording coal of the purest and best kind. In the neighborhood of Pittsburg, the lower part of this mass for about one foot in depth, abounds in thin seams of pyritous shale, and is hence rejected by the miners. Above this part of the seam, there is the stratum of blue or black clay-shale, dividing it from the coal roof. It is hard and compact when first dug out, but on exposure to the atmosphere crumbles down into a soft clay. It is generally free from gritty particles and with a similar layer in the coal next the roof, it has been advantageously used in the manufacture of fine bricks. Above it is the roof coal, consisting of a bed of coal with shale intermixed in numerous thin layers. Towards the bottom this is a band of true coal from one to two feet thick; the higher layers are generally thin. The coal in this part of the seam, is in itself of good quality, but the expense of separating it from the accompanying slate is generally too great to justify the attempt. Hence the miners along the Monongahela, content themselves with extracting the lower division, leaving the remainder to form the roof of their drifts. In Allegheny county the main breast varies from five to six feet in thickness, but as we ascend the Monongahela and approach near the Chesnut ridge, it enlarges much, yielding in some places from eight to nine and a half feet of pure and compact coal. The quantity of pyrites in the clay and shale accompanying the coal, is very considerable; these layers readily crumble, and when exposed to the atmosphere are generally covered with *copperas*, produced by the chemical action upon the sulphuret of iron. These natural incrustations of copperas are very common throughout the district. In many instances, the coal of the roof has been precipitated by a slipping of the hill side upon the lower part of the seam, in which case the latter has often taken fire from the heat evolved by the chemical decomposition just mentioned.—This has occurred particularly at the mouth of the Redstone creek, in Fayette county, where the overlying shale, has been baked and reddened by the combustion. The shale and clay of the upper part of the seam, abound in casts and impressions of plants, many of which are very beautiful.

In tracing this seam of coal, it was an object from the commencement, to ascertain the dip and range of so important a deposite, but we were soon made aware, that this could only be accomplished by a series of accurate measurements of the height of the coal itself, and the adjacent strata at different points throughout the country.—From the peculiar character of the region, a knowledge of the dip is of little use for this purpose, being generally affected, if not produced by the manner in which the incumbent strata have been cut through at the time of the original denudation of the country. The measurements which were made for this purpose were merely experimental, and their completion may be more properly left to a later stage of the survey. Enough was developed to render it highly probable that this bed observes a nearly horizontal position, dipping very slightly to the south-west, with undulations running through it, from north-east to south-west parallel to the axis of the Chesnut ridge, and affording a miniature representation of what has taken place on a larger scale along the south-eastern side of the whole coal field, near the Allegheny mountain. Over the most considerable of the lines of elevation, the only one which has yet been minutely examined, the upper beds of coal have been swept away, and the inferior strata exposed. The anticlinal axis alluded to, runs parallel to the western base of the Chesnut ridge, keeping usually within about seven miles of it. It may be seen about four miles west of Greensburg, Westmoreland county; passing thence south-west, it may be detected a few miles west of Mount Pleasant and Connellsville; three miles west of Uniontown, Fayette county, and in the vicinity of Mount Morris, Greene county. East of this line a few miles, the coal resumes its western dip, and is found regularly cropping out along the base of the Chesnut ridge, particularly near Uniontown, Connellsville, Mount Pleasant and Youngmanstown. Its northern outcrop is believed to be about five miles north of Pittsburg, passing through the northern parts of Westmoreland county, and that part of Beaver which lies south of the Ohio river. As we approach the Kiskiminetas, the coal is found on the summit of the highest hills, and the lower members of the series begin there to make their appearance. Whether the Pittsburg coal seam extends north of the Kiskiminetas is not known, as no examinations have yet been made in that district. Its extension in that direction is not, however, probable, for the coal seams at Saltsburg, Leechburg and other places on the river, belong to the strata below the Pittsburg series.

A more full account of this inexhaustible bed will appear in my final detailed report, where all its Geological relations and its depth below the surface of the country, at almost every point as ascertained by measurement and calculation, can be exhibited by the aid of drawings and Geological maps.

No. XVIII. Shale.

Reposing directly upon the coal seam, we observe a bed of shale passing generally, but not always into the overlying sandstone. The line separating it and the roof-coal is usually well defined. In the neighborhood of Pittsburg, where it forms in connexion with the next member of the series—the summits of the hills, we find it a brown friable and compact shale of a ferruginous appearance. In common with other strata, it is composed of a mixture of sand and clay, the shale enclosing sandstone layers of greater or less thickness, which increasing as we ascend, in number and size, pass gradually into a compact sandstone. In the northern part of the district, this stratum is remarkable for the quantity of mica that it contains, which causes the sandstone layers to split into large slabs, with a glittering micaceous surface and imparts to them at the same time a crumbling texture. In other situations it abounds in vegetable impressions, apparently the stems of arundinaceous plants, &c. Very frequently, particularly in the lower part, it is a very soft brown and black shale, readily disintregating and has a splintry fracture, breaking off in long, thin prismatic fragments like the splinters of decaying wood. The surface is often covered with an efflorescence, a part of which is copperas. There are two varieties of this encrusting matter, the first, a salt of a pure white color in delicate crystals, and a greenish yellow mass, into which the former passes, by longer exposure to the atmosphere.

In Fayette county, it contains a thick bed of compact, distinctly laminated black shale, resembling in the harder parts, a roofing slate; the other layers are very soft and black. This includes a layer of coal one foot thick. Similar bands, from one to several inches in thickness, are often observed running irregularly through it. Iron ore in small quantity is not rare in it, either dispersed in irregular nodules or in thin layers. The most considerable deposite of this kind, hitherto observed, is in Connellsville township, Fayette county, where it imbeds two layers of argillaceous ore, the uppermost a band of blue nodules, each from one to two feet broad and four inches thick. The whole stratum varies much in its dimensions, being in some places very thick, and in others only from five to ten feet. It may, however, be estimated at thirty feet average thickness.

No. XIX. Sandstone.

At various places along the Monongahela, for example: in the vicinity of Brownsville, and higher up the river, we behold a heavy bed of sandstone resting on the preceding. It is in general, a grey slaty sandstone, alternating with layers of brown and black shale. It varies much in compactness and thickness. Frequently it can be observed from a great distance forming white ledges along the hill sides and the banks of the larger streams. In the southern part of the district we find it in its greatest development, being there frequently quarried as a building stone. Quarries of this rock are opened at Williamsport, on the Monongahela, and at several other points. Some layers of the stratum afford a fine stone of a light gray and yellow color, but of variable texture. Others are full of ferruginous concretions which render these bands difficult to dress. Carbonized remains of the ancient vegetation of the coal are not uncommon in this stratum, but no other fossils have been observed. On the steep banks of the river and in other situations, particularly at the mouth of Ten Mile creek, and for some distance lower down the Monongahela, the sandstone appears to rest immediately upon the coal. Such appearances are not unfrequently caused by slides, which bring down the heavy sandstone shelf, over the soft and yielding beds of the intervening shale. It is not improbable, however, that No. XVIII is sometimes wanting, and that the present stratum is to be found in contact with the Pittsburg coal seam. Average thickness, twenty-five feet.

No. XX. SHALE.

Directly over the sandstone there lies a stratum of yellow and brown shale, imperfectly laminated with layers of sandstone, alternating in it. One portion of this rock is sometimes a tough and hard slate of a greyish color, containing grains of pure quartz.—When soft, it is frequently pressed down upon the underlying sandstone, whose cavities and fractures it fills in a singular manner with a mass of ferruginous clay, shale, and sometimes impure coal. No part of this stratum seems fit for building purposes. Thickness, twenty feet.

No. XXI. THE GREAT LIMESTONE DEPOSITE.

This is the most extensive and valuable calcareous deposite in the valley of the Monongahela or any where else in the western counties of the State, for the limestone beneath the Pittsburg coal is comparatively thin and of little importance as a source of lime for masonry or agriculture. This ample stratum, however, affords an inexhaustible supply wherever it is exposed in any part of the district. From the vicinity of Pittsburg to the southern State line, and from Chesnut ridge to the Ohio river, it may be traced continuously, either on the summits of the hills, or what is more frequent, forming shelves or natural pavements along the beds of the smaller streams. It is a non-fossiliferous deposite, no fossils having been hitherto found imbedded in it, notwithstanding the frequency with which it has been examined in tracing its range through the country. The variation in the thickness and particularly in the composition of this stratum is remarkable. It consists of numerous beds of limestone separated by thin seams of shale. These beds are sometimes in contact, at others they include thin layers of shale from one to eight feet in thickness. Instead, however, of these partings of shale, we occasionally meet with dividing bands consisting of a sandstone which is calcareous, effervescing slightly with acids, and passing sometimes insensibly into the limestone. The limestone itself, is generally of a blue color of various shades, is excessively hard and breaks with a semi-conchoidal fracture. At other times the layers are black or light yellow, and contain transparent specks of crystallized carbonate of lime. The latter variety is frequently very beautiful, and apparently hard enough and fine enough in texture to receive a good polish. If so, it would make a handsome ornamental marble, although the thinness of the layers would interfere with its extensive use for architectural purposes. The black kind is very hard, of a slaty structure, and gives out a fœted or bituminous odour when bruised or struck. This kind is generally found in contact with the interposed black shale. In some instances it passes insensibly into it, when the shale becomes a black calcareous slate, splitting readily into smooth plates and effervescing freely when touched with an acid. Most generally the shale is very soft, of a deep blue or yellow color, imperfectly laminated, and decomposing readily into a soft clay. Not unfrequently, it contains layers of calcareous nodules. Occasionally, it is very soft and black, resembling the outcrop of a coal seam. In the southern part of the district, instead of shale, we find two thin layers of *coal* separating the limestone beds. The largest of these is two and a half feet thick, and has been opened in several places as a *coal* seam. Over what extent of country it will prove to be continuous, must be determined by future observations. The coal is of a good quality, very hard, breaks into lamellar fragments, and is separated from the layers of hard limestone by only a few inches of black slate. This band of coal has the appearance of being compressed by the limestone. By way of distinguishing it, we may entitle it the limestone coal seam. The other band embraced by the limestone, is about one foot thick. It is probable that several thin seams of coal of a few inches in thickness would be observed in this stratum, if the crumbling nature of the dividing shale did not tend to conceal them. In these shaly partings we sometimes meet with layers of limestone, in nodules of a large size and regular form, as if in these portions of the deposite, there had not entered quite enough of calcareous matter to produce a continuous bed of limestone. The consideration of these appearances, would, if we had space for the discussion, throw some curious light on the original formation of this important stratum.

This well characterized member of the series is readily recognized, and is very generally exposed in the ravines and hill sides, but being a rather variable mass as regards its minuter features, it is by no means easy to ascertain in every case, its precise composition. The quarries established in it, are generally mere strippings of the upper layers. Such is the case with those in Wilkins and Monongahela townships, Allegheny county, where the rock seems to thin off towards its northern outcrop. An idea of the manner in which it varies, may be obtained from the following sections:

Section taken at Brown's run, near Germantown, Fayette county.

1.	Hard blue limestone in layers,	18 feet.
2.	Blue and black shale, "	15
3.	Limestone and calcareous shale,	5
4.	Coal, 2½ feet with one foot of black slate beneath,	3½
5.	Hard blue limestone,	5
6.	Sandstone in layers,	10
7.	Slate, upper part soft, lower black and laminated,	3
8.	Hard blue limestone in layers,	6
	Whole thickness 65½ feet,	65½

Section measured at the south branch of Ten Mile creek, near Jefferson, in Greene county.

1.	Limestone in layers,	12 feet.
2.	Shale, soft and blue, full of calcareous nodules,	4
3.	Grey sandstone layers,	1
4.	Limestone in layers,	7
5.	Calcareous sandstone, passing into the limestone,	7
6.	Blue limestone in layers,	20
	Thickness, 51 feet,	51

Section at Brownsville, in Fayette county.

1.	Limestone, hard, in layers,	25 feet by estimation.
2.	Shale, black,	5
3.	Sandstone, slaty,	18
4.	Black calcareous slate, regularly laminated,	8
5.	Limestone, slaty,	6
6.	Hard blue limestone,	10
	Thickness, 72 feet.	72

It is not, however, in every part of the district, that this deposite attains this full developement. In Allegheny, and the northern part of Westmoreland county, it is met with, covering the highest hills with its lower layers. These are sometimes seen capping the insulated summits of the hills, and forming a natural pavement, completely detached from the surrounding strata. Advancing towards the south, we find it gradually sinking under the hill tops, and showing itself lower down on the sides of the creeks and small streams, and becoming at the same time thicker.

Along the western base of the Chesnut ridge, this stratum rises to the surface, with a gentle inclination, in company with the other members of the series, being well exposed on the Loyalhanna and Youghiogheny rivers.

Appearing as it does on the Ohio river, at Wheeling, it is not improbable that this is the same bed of limestone described by Dr. Heildreth, as No. XXIV, in the first annual report of the Geological survey of Ohio. This description applies to it very exactly.

There are but few of the streams or even small runs emptying into the Monongahela, from Elizabethtown to the Virginia line, along which this stratum is not well exposed, its beds either forming a series of horizontal steps or platforms in the smaller water courses, or steep and smooth escarpments on the hill sides. On its almost incalculable value to the agriculture of our south-western counties, I need not dwell, but I cannot refrain expressing a sincere regret that the importance of lime as a fertilizer, should continue to be so much overlooked. It is proper in this place to observe that the shales between the limestone beds themselves, are frequently very calcareous, and are consequently, in many cases, a genuine *marl*, both as respects their composition and their agency upon the soil.

No. XXII. Shale.

Resting on the upper part of the preceding limestone, there usually occurs a thin, but well marked bed of shale, of varying thickness. The predominant colors are blue and yellow, and it is soft and imperfectly laminated. A bed of coal one foot thick has been detected in it, but this is not continuous. Thickness ten feet.

No. XXIII. Flaggy Sandstone.

The next rock in order is an important bed of sandstone distinguished by its slaty and thinly laminated structure, in consequence of which it affords an abundant supply of beautiful flagstone. It is well exposed at the town of Brownsville. The flags are obtained by splitting the rock with wedges, and can be procured of any size from the thickness of one-fourth of an inch to one foot or more. It owes its slaty structure and ready cleavage to the abundance of mica distributed in thin sheets through it. It is generally fine-grained and of a light grey color. Good flagstones are obtained from it at Brownsville and other places. The flaggy structure being owing to the accidental presence of mica—when this ingredient is wanting or deficient in quantity, the rock then becomes a compact sandstone, and the lower part is sometimes quarried as a building stone. Vegetable impressions abound in it in some localities. Its general thickness is about fifteen feet.

No. XXIV. SHALE.

Over the above we find a bed of shale, generally of a brown or yellow color, and often containing vegetable impressions. This stratum has not every where been recognized; the overlying limestone next to be described, sometimes resting on the preceding sandstone.

No. XXV. UPPER LIMESTONE.

This is a deposite of limestone, similar in character to the great deposite, No. XXI, but of less thickness and greater uniformity of composition. It consists of five or more layers of hard blue limestone, separated by a parting of shale, which is generally four feet thick, and which contains calcareous nodules and in one instance a layer of coal about one foot in thickness. Thickness of the whole mass about eight feet.

No. XXVI. SANDSTONE AND SHALE.

We come next to a very important but variable bed of sandstone and shale. In Greene county it is a solid bed of sandstone, of a light grey color, and is generally coarse-grained. In other parts of the district the sandstone is in thin layers, from one inch to two feet in thickness, separated by soft yellow and brown seams of shale.—When the arenaceous layers are abundant, the stratum is a true sandstone, but when deficient, it passes into a bed of shale, the change depending upon the greater or less quantity of sandy particles present in the mass.

There is some reason to believe that this stratum contains a seam of coal three feet in thickness, which may probably be the one seen at Brownsville, at Limetown and at Elizabethtown, and which occurs at various points upon the hills in the northern part of Washington county. The precise situation of this seam we have not yet been able satisfactorily to determine, nor has it been possible, indeed, to ascertain whether it is not identical with the limestone coal seam just mentioned. This stratum is very little exposed, in many places the shale being easily buried by the fallen materials of the hill sides. In the eastern part of Greene county, this coal is not seen; there the stratum is a thick bed of alternating sandstone and shale, and is well exposed beneath the upper coal seam, to be mentioned presently. Owing to its occurring frequently in regularly divided layers, from a few inches to many feet in thickness, it can be obtained in handsome flags, which are of a light grey color, are slightly micaceous and easily worked. Thickness thirty-five feet.

No. XXVII. Shale.

This underlies generally the upper coal seam to be next alluded to, but sometimes it is very thin or even entirely wanting. It is a soft yellow shale, full of calcareous concretions, and the upper part adjacent to the coal is frequently converted by the weather into a soft blue clay. Thickness five feet.

No. XXVIII. Coal.

We have now arrived at a seam of coal, that for importance ranks next to the Pittsburg seam, every where throughout the southern part of the valley of the Monongahela. Although affording generally a coal of very excellent quality, it is not worked except in Greene county and the adjacent parts of Washington county. Over the northern portion of the district it has been removed from the surface by denudation. It is about six feet thick and rests on the preceding shale, or, where that is absent, on the underlying sandstone. It is divided near its centre by a band of soft shale, which varies much in thickness. The lower part of the seam affords the best coal, and with care in extracting the slate, it forms an excellent fuel; the upper part is less pure, and has a slaty structure breaking into pieces of a prismatic shape. The adjacent slate is very full of pyrites, frequently containing large nodules of that mineral, by the decomposition of which copperas is abundantly produced, forming a coating on the surface of the coal and the included shale.

This seam of coal is met with in the high hills in the neighborhood of Brownsville, and also about two miles east of Waynesburg, in Greene county. Here it is seen in the bed of south Ten Mile creek, emerging from beneath the elevated ridge of country which extends through the centre of that county, and forms the high land which separates the tributaries of the Ohio river from those creeks which empty into the Monongahela. Passing beneath this table land it is again met with, as it re-appears on the western side of the county along the south fork of Wheeling creek, a few miles from the State line. From the vicinity of Waynesburg, it spreads through the eastern part of Greene county, where it is worked extensively in Jefferson and Cumberland townships. This bed of coal will, when the country becomes more thickly settled and better cleared, be considered a highly valuable deposite, and will then be found to have a much wider range than is now attributed to it.

No. XXIX. Shale.

Overlying the previous coal seam, we notice a bed of brown and yellow shale. It is of great thickness and seems to have been compressed by the superincumbent sandstone. On the south branch of Ten Mile creek, it in some places becomes very thin, though even there it is a well marked stratum. Generally, it is covered with an incrustation of impure copperas, and small quantities of iron ore are sometimes enclosed in it. It is often but two feet thick, separating the coal at its outcrop from the overlying sandstone. Average thickness ten feet.

No. XXX. Coarse Brown Sandstone.

This is the largest bed of sandstone belonging to the upper part of the series. It is met with at Brownsville, in the high hills on both sides of the river, and extends thence through Fayette and Greene counties to the State line. This stratum is best developed in Greene county, where it extends from Waynesburg eastward to the river, capping the highest hills in the neighborhood. At Brownsville, where it has been quarried, it occurs as a coarse brown sandstone of a singular aspect, varying much in texture and composed of minute water-worn grains of white quartz. Two varieties of the rock may be distinguished, the first has a brown color, consists of large grains held together without any apparent cement, and on exposure to the atmosphere, crumbles rapidly into a coarse sand of a sharp grit. The other variety has a finer grain, is of a grey color, and would make a good building stone.

In Jefferson and Franklin townships, Greene county, where this member of the series is well exposed, it forms a thick and massive stratum. In some places it is a soft slaty sandstone, externally of a yellowish color, but in other situations its texture is coarse and the prevailing color a dark brown. Large blocks of it are frequently strewed over the hills. Occasionally it graduates into the underlying shale, but in general its inferior surface is well defined, it being a very compact and heavy rock.

This stratum in the northern parts of its range, has been stripped off from the surface by the action of the retreating waters. On the high hills adjacent to Hillsborough, in Washington county, rounded boulders of a coarse sandstone are found, which have evidently been derived from this stratum; in like manner in Menallan and Redstone townships, in Fayette county, similar blocks are found, scattered in large fragments over the tops of the highest hills. Average thickness thirty-five feet.

OF THE STRATA ABOVE THE PITTSBURG SERIES.

It is believed that no part of the district contains rocks superior in their order of stratification to those just described, if we except the narrow belt of country a few miles in width, which forms the dividing land between the Ohio and Monongahela rivers, and which extends from the town of Washington southward, through Greene county to Dunkard's creek, on the Virginia line. The hills here are generally high, and not well cleared, affording few exposures adapted to minute Geological examinations.

So far as they have yet been investigated, these upper strata consist of thin beds of shale, sandstone and limestone, imbedding no deposites of much value, excepting iron ore, which there is reason to believe exists in some of the upper shales. When engaged in this portion of our exploration, the season was too far advanced to enable us to make any very satisfactory examinations. I may, however, subjoin the following section, the only particular enumeration of the strata above No. XXX, that we have been able to construct from actual observations and measurement. It is of course imperfect, but will be rendered complete in the detailed investigation, which this district will require hereafter.

Sect. 31.	Shale, blue and friable,	7 feet.
32.	Coal, 20 inches; this is worked in several places.	
33.	Shale, blue, with calcareous nodules,	3
34.	Limestone in layers,	4
35.	Shale, soft, blue and badly laminated,	4
36.	Limestone in three layers,	4
37.	Shale, blue and yellow,	10
38.	Sandstone, very slaty, splitting into thin layers,	20
39.	Shale, brown and blue,	10
40.	Coal,	1
41.	Shale, brown and blue,	4
42.	Sandstone,	20

This section is the result of observations made in Waynesburg, in Greene county.

OF THE COUNTIES NORTH OF THE OHIO RIVER.

Transferring our attention in the next place, to that region of the State which lies north of the Ohio and west of the Allegheny rivers, let us enter upon a brief enumeration of the strata, as developed in this north-western portion of the basin.

The lateness of the period in the summer, when the explorations in this district were begun, owing to the unavoidable delay in procuring the services of a competent assistant, combined with the extent of country which it was necessary we should traverse, in the way of reconnoissance, preliminary to a systematic and detailed survey, besides certain impediments, incident to the examination itself, arising out of some local irregularities in the stratification, have all conspired to prevent our arriving at as complete a knowledge of the range and relative positions of the rocks and their imbedded mineral deposites, as we obtained in the more easily explored region of the valley of the Monongahela. Nevertheless, I am enabled to present such a sketch of the Geology of this portion of the basin, as will show the nature and situation of its mineral resources, and convey a general idea of the progress already made in the exploration; which, in reference to the State at large, is indeed the principal objects of my annual reports. In a section of the State where the investigation may be said to have been only commenced, there are many local facts and numerous and minute measurements already recorded, which are necessarily too incomplete to make it proper to refer to them at present. They are reserved in order to incorporate them with fresh details to be hereafter collected, when their utility and their important practical bearings, (now liable, possibly, to misinterpretation by those who are unacquainted with the proper mode of tracing the mineral deposites of an extensive region,) will justify any present delay in submitting them to the public.

STRATA OF THE NORTH-WESTERN PART OF THE STATE, WHICH LIE BELOW THE COAL MEASURES.

For reasons already stated, these will claim, at present, only a passing notice. Adopting as a convenient Geological boundary, the escarpment facing the north-west, or, in other words, the north-western slope of the line of hills, which stretches from near the State line, north of Warren, south-westward by Meadville, to the neighborhood of Sharon, we shall find the country included between that limit and Lake Erie, embracing chiefly Erie county and part of Crawford, to consist of strata of our formations VIII, XI, and X, but principally of those of formation VIII. Minute research may possibly enable us to detect hereafter, in the thin seam of arenaceous limestone found near the base of these hills, at Meadville, evidence of its being the final thinning away of formation XI, already described, as exposed along the south-eastern side of the basin on the flank of Chesnut ridge. The line of hills above traced, marks the extreme north-western margin of our great bituminous coal field, being capped by the conglomerate of formation XII, generally the immediate substratum of the coal measures. The inferior destructibility of this rock, compared with the softer ones between it and the lake, by causing a less degree of denudation of its surface by the retreating waters, is the reason of its forming the edge of the table land upon which all the coal reposes, in a very gentle inclination to the south or south-east.

The easily decomposed shales and argillaceous sandstones of formation VIII, have furnished much fertile soil to parts of Erie, Crawford, and the adjoining counties. Thin bands of more or less pure limestone, occasionally imbedded in this formation, deserve to be especially examined, in order to learn their true range and position, and to detect any possible connection they may have with the valuable deposites of calcareous *marl*, so abundant in some of the low grounds of this region, Pymatuning and Conneaut swamps for example. An attention to whatever may bring to light, in these localities, the existence of so useful a fertilizing material, must be important to the practical objects of the survey, and will influence, in part, our future researches in this region.

Approaching the base of the chain of hills, capped by formation XII, we meet with slates occupying a rather higher place in the series, which, judging from many of their external features, seem to be referable to formation IX, and a portion of them, probably to formation X. There is a difficulty in defining, at least at present, the respective limits of these three formations, or indeed in establishing unequivocally the separate existence of the two last. In truth, strong doubts may be started, whether the alternation everywhere more or less observable between formations VIII and XI, and also IX and X, may not comprise, in the part of the State now before us, nearly the entire mass of this portion of the series, implying a more intimate blending of the several materials, as they reached this part of the bed of the ancient sea, than took place in districts more to the south-east, where they have been separately super-imposed.

A reference to the stratification, as we behold it in the vicinity of Meadville, will tend to convey a tolerably exact conception of the nature of the beds of rock which occupy the four hundred feet of depth below the base of the conglomerate stratum, (formation XII,) which there caps the hills, forming part of the general margin of the coal field.

These hills, on the north and south of the town, are at their greatest elevation, four hundred and eighty-eight feet above the bottom of the canal, and expose the upper strata especially, with some degree of distinctness. The lower ones are not so continuously exhibited to view, making it more difficult to determine their true order of succession.

Near the level of the canal, the beds are of brown slate and sandstone, and over this we find a thin bed of clayey shale, then the sandstone repeated, and then another layer of red and grey shale, two or three feet thick. Near the outcrop of this bed of clayey shale, a spring issues near its upper surface, encrusting all the rocks beneath it with a coating of carbonate of lime. At a higher level are seen thin beds of calcareous shale, some of which abound in fossil shells and other organic remains. From this shale to the height of one hundred and fifty feet, occur alternations of coarse, brown sandstone, and thinly laminated bluish slates, and flaggy olive sandstones and olive slates. At that height we meet a bed of blue shale four feet thick, and over it brown sandstone and olive slate, until we reach two hundred and thirty-five feet. Here we encounter a bed of *sandy limestone* two feet in thickness, which, as it is a peculiar rock, and remarkably continuous for so small a stratum, deserves particular notice. It is compact and exceedingly hard, containing a large though variable proportion of siliceous or sandy matter. In lies in large and nearly square masses, the angles of which are more or less rounded off, owing to the readiness with which the lime is dissolved out of the rock. By the removal of this ingredient, and the oxidation of the iron in the stratum, it acquires a brown siliceous crust, sometimes thick, indicating, it is to be feared, too large a proportion of sandy matter to qualify this rock to be converted into even an impure lime. In an attempt once made, the excess of sand in the rock, produced with the lime a slag. In such cases a more moderate degree of heat will sometimes prove more successful. Under the limestone, in a massive bluish sandstone, we find thin layers of an impure *iron ore.*

Ascending from the limestone, we pass thick beds of brown and bluish sandstone, some of which latter are slightly calcareous, thin beds of fossiliferous and calcareous slate, succeeded by others of brown and blue shale.

At the height of four hundred and twelve feet, we arrive at the base of the great bed of conglomerate, consisting of sand and of siliceous pebbles, never larger than a common marble or a large pea. The same rock is seen at the height of four hundred and fifty feet. Its soil is different from that of the rocks beneath it, being said to be better fitted for wheat, and sustaining a luxuriant growth of chesnut trees.

The hill to the south of the town has a less elevation than that to the north, by nearly fifty feet; but as the soil here contains scattered fragments of coal, a fruitless search was once attempted for coal, which a moderately shallow boring would have shown could not exist.

On French creek, seven miles south-east of Meadville, the conglomerate caps the hills, which are there very high.

Of the general face of the country, on the north-western side of the coal field, it may be instructive to make some mention in this place, as tending to assist in forming a correct notion of the position occupied by the coal and other mineral resources in this quarter of the State. In the western part of Mercer and Crawford counties, the table land supporting the coal measures, is intersected by long, straight and rather wide valleys of denudation, leaving the upper shale, containing the coal, in long parallel intervening ridges, which range in a north by west and a south by east direction. The largest streams pursue the valleys, merely crossing through the ridges out of one valley into the next, but the small tributaries rising in the hills, find their way transversely down their flanks by ravines, into the main valleys. From the Ohio river northward, the general plane of the country gradually rises, but with a very gentle inclination. From the mouth of the Beaver to the surface of Conneaut lake, the ascent is only four hundred and eighteen feet. The tops of the highest hills near New Brighton, are about five hundred feet above the Beaver, at its mouth. At the bend of the Shenango, where the canal is two hundred and forty-one feet above the mouth of the Beaver, the hills rise three hundred and ninety-five feet more, making six hundred and thirty-six feet above the mouth of Beaver creek; and Pymatuning ridge, in Mercer, is about fifty feet higher than these. At Meadville, the canal is four hundred and twenty-three feet, and the hills nine hundred and thirteen feet above the former point, the mouth of Beaver. We perceive, therefore, that the actual ascent of the plane, including the summits of the hills, from the Ohio river to the margin of the coal basin, hardly exceeds four hundred feet. Nevertheless, gentle as this rise in the land towards the north appears, it has the effect of spreading out the valuable beds of coal, iron ore and other materials in that direction, over a much wider space than they would have covered, had the surface of the district been entirely horizontal. After thus supporting the lower strata of the coal measures, this gently inclined plane sinks suddenly to the lower plane or terrace which borders, in a broad belt, the southern shore of Lake Erie, the surface of which is only eighty feet lower than that of the Ohio, at the mouth of the Beaver. Throughout almost the entire extent of this upper plane, the lowest bed of coal, with its accompanying iron ores, still clings to the surface, and though discovered in few places, will ere long, it is believed, be developed at many points, where its existence is not now suspected.

Along the line of the canal, from the Conneaut lake to Sharon, the coal already found in many places, will be traced and ultimately opened in a multitude of localities; for the lines of levelling which have been executed, show that the coal rises but little more rapidly to the north than the surface of the country itself. One valuable locality where it can be readily mined, and from which it might be conveyed away by the canal with great facility, would be the Bend hill, on the Shenango. Although the coal has not yet been discovered at this point, the measurements and observations made tend to give considerable confidence in its being soon found there, if the excavations be judiciously conducted.

The subjoined estimate is presented for the sake of showing the advantages to this section of the State, which may be anticipated from an early development of its coal beds, which, situated on the northern margin of our coal field, have open to them, so soon as the Shenango shall be finished, the boundless market of the region of the lakes.

Expenses of mining and transporting the coal from the Shenango to Erie and Buffalo.

At the mouth of the mine the coal will here cost, per bushel,	1½ cts.
Cost of delivering it from there into the boats,	1
Transportation to Erie, including lockage,	6
Whole cost delivered in Erie, per bushel,	8½

The present market price of coal, in Erie, is twenty-five cents.

To convey it on to Buffalo, would swell the expense about two cents more per bushel.

Sharon, the neighborhood of Clarkesville, and of Greenville, and other places similarly well situated with these and the Bend hill, will supply the northern market with coal, under circumstances of cost at once highly advantageous to our own citizens, and to the consumers to whom this excellent fuel is becoming daily more indispensible.

At a point about eight miles west-south-west of Meadville, and three miles south of Conneaut Lake, coal is found, and the conglomerate, (called in this part of the State, the "Pebbly rock,") occurs exposed about three-fourths of a mile to the southward. Upon levelling the surface between these places, the bottom of the coal was ascertained to be level with the top of the conglomerate, but the real direction and the extent of the trivial dip in this place has not yet been determined.

The coal which lies near the surface, has been opened only recently, and of course near the outcrop it is somewhat broken. It is, however, of excellent quality, especially for the use of the blacksmith, being of a bright lustre and pure. The bed measures from three and a half to five feet in thickness. This coal sells at Meadville for seventeen cents per bushel.

About one hundred feet below the conglomerate in this vicinity, a bed of blue shale contains many seams of an impure variety of iron ore of the kidney form. A bed of arenaceous limestone, closely resembling that at Meadville, occupies at this place, the same relative position to the overlying conglomerate which it has there, being about two hundred feet above it. The sandstone overlying it, is also very similar, though it abounds more in the fossil vegetable impressions, called *fucoides*. In this neighborhood there are many high hills, which promise an abundance of coal, though the inhabitants have never, until now, suspected its existence. The natural exposures are not good, and a very critical examination made by the aid of instruments will be requisite before its exact position can be ascertained.

Iron ore has been found near the coal, and below the conglomerate. Travelling towards the south and south-east, the conglomerate and coal gradually descend in height to the level of the lower hills. Three miles south-west of Greenville, coal is found at Yockstemmer's, two hundred and forty feet above the bottom of the canal, from which it is distant a mile and a half to the westward of it. It here lies very irregularly, showing a difference of level of seven feet in the space of a few rods. It is about three feet thick, and of the variety called *slaty cannel coal*. At this point the conglomerate lies above the coal now spoken of, separated from it by from twenty to twenty-five feet of argillaceous strata.

At Georgetown, the conglomerate, coal and iron ore, are all found a little below the highest summits of the vicinity. The coal is about three feet thick, of a dull black, and in structure and aspect, is a slaty cannel coal. Iron ore in great abundance has been thrown out in excavating the drift at the mouth of the coal mine.

Above the coal to the height of about twelve feet, the hill side abounds in fragments of a bluish conglomerate, containing the usual white pebbles, but the adjoining sandstone is more sparsely studded with them. In many places in the neighborhood of Georgetown, the conglomerate, well marked in all its characters, is seen overlying the coal. Between them, there usually lies a shale containing several seams of excellent iron ore. Two in particular, which are separated by only a foot of shale, measure in aggregate thickness, twelve inches, the upper one seven inches, the lower, which is of a beautiful blue color and fine texture, five inches.

A small furnace is now erecting to smelt the ore, (a mile or more, however, from the spot where the foregoing measurements were made.)

It is of a rather novel design. The blast is to be propelled by a steam engine, in which the steam will be generated by the heat supplied from the stack of the furnace, to which the boiler is to be attached. It is a small quarter stack furnace, and is, strange to say, with one exception, the only furnace in Mercer county.

Along the margins of several runs which enter the Little Neshanock, our explorations brought to light a bed of arenaceous limestone, exactly corresponding in its position and quality to the seam already alluded to, as occurring at Meadville and Conneaut lake.—Not far below it, my assistant, Mr. Hodge, found at Mr. Milnor's, where the township line crosses the Little Neshanock, a bed of blue shale from ten to fifteen feet thick, containing *eleven* layers of iron ore of pretty good quality. The aggregate thickness of the ore was estimated at a foot and a half. The shale appears to be adapted to making a good fire brick.

This neighborhood seems to possess claims as an iron manufacturing district, not only from the abundant supply of good ore in it, but from its capacity to furnish a competent quantity of charcoal, much of the land being still covered with an exceedingly heavy growth of hard wood. Bog iron ore has been found in considerable amount, but its purity is somewhat problematical.

Approaching the town of Mercer, on the turnpike, we soon encounter a thick bed of sandstone, which is of various colors, or red and mottled in its upper portions. It is full of thin streaks of iron ore, which impart to it a peculiar feature. Near its base the stratum is very white. It lies above the conglomerate, and its thickness is at least one hundred feet. Half Moon Swamp lies below this, its level being about the position of the coal bed. This sandstone stratum passes under the town of Mercer.

A bed of slaty cannel coal like that at Georgetown, has been discovered at a place called Orangehill, in Pymatuning township.—About two hundred feet below it, we found a bed of arenaceous limestone one foot thick, one mile and three quarters from this coal.—East, nearly thirty-three degrees north, the same bed is exposed twenty-three and a third feet higher in level, giving a dip of thirteen and one-fifth feet to the mile, estimated in the direction west, thirty-three degrees south, though this may not be the direction of the maximum dip of the stratum. The land between rises to the height of one hundred and ten feet above the lower coal bed. This is also the height of Pymatuning ridge, where search has been made for the coal seam, by digging numerous shallow pits at one and a fourth miles south-east by east of the spot where it has been opened, but without success. On levelling from the coal to this spot, the conglomerate was passed lying about fifteen feet above the level of the coal.

Should the coal be found hereafter below the lowest stratum of brown shale, which is above the conglomerate, it will prove that a sensible dip, or, what is far more probable, a dislocation of the strata, occurs in the intervening distance, equivalent to a descent of forty feet to the mile, in a south-east by east direction.

SANDSTONE STRATA, AFFORDING QUARRIES ALONG THE SHENANGO.

In the neighborhood of "Big Bend," some important quarries of sandstone have been opened to supply materials for the construction of lock No. 15, and the dam near it, belonging to the Shenango navigation.

The first of the quarries is at an elevation of about one hundred feet above the canal, and one mile higher up the valley than the lock. The stone is employed in the slope wall and bridge piers. It is a firm, bluish sandstone, slightly calcareous, and lies in a solid mass, thirty feet at least in thickness. It may be quarried in blocks, whose greatest thickness is about two feet. A temporary rail road conveys the stone upon little trucks, regulated by a break. This is the most convenient quarry to the canal. The stratum extends down the valley to Sharon, three miles above which it is quarried in another place, and it occurs at Meadville, where stone has also been extracted from it. It may be readily recognized, by its bluish tint and slightly calcareous properties. Between this rock and the conglomerate which overlies it at a considerable height, there is a massive stratum of brownish sandstone, which might be readily quarried on the Shenango, if it were thought desirable. It yields good stone two miles south-south-west from Conneaut lake.

Both these valuable strata not making their appearance at the surface near lock No. 15, the contractors not being aware that they range in nearly the same continuous plane under all the hills, have passed over them on the northern side of the Shenango, while they have gone beyond the siliceous conglomerate to establish a quarry in the thick bed of sandstone on the very summit of the hill, which is here nearly four hundred feet high. To procure some of their stone, they even go down on the *other side* of the hill to the conglomerate, simply because it was there exposed. Directly opposite, they pass over all the lower beds of sandstone unheeded, to the conglomerate, and until recently, they passed by this and continued a mile further, by an expensive road constructed expressly for the purpose, to procure their stone from the stratum of the red and variegated sandstone exposed on one of the highest summits of the Shenango hills.

On the top of the Keel ridge, four and a half miles from Sharon, the same bed of red and variegated sandstone shows itself, and is quarried to be taken thence to lock No. 6, below Sharon, a distance of at least four miles, while an inexhaustible supply of stone, certainly as fit for the purpose, might be procured in the immediate vicinity of the work from the other strata enumerated.

The above details are introduced for the purpose of impressing upon the engineers the great importance to the State, or to the companies constructing public works, of themselves exploring, somewhat in detail, the stratification in the neighborhood of their surveys, and of doing this prior to issuing their proposals to contractors.

The contractors on the works of internal improvement in the United States, are at present, a large majority of them, new in their business, and untaught in even the rudiments of practical Geology, a subject of all others, the plainer principles of which it behooves them to understand. The consciousness of this makes them uncertain of a supply, in every case of apparent difficulty, in procuring their materials, and operates as a tax, and often a very heavy one, on the State or other parties constructing the work. Add to this the consideration, that many of them come from distant quarters at short notice, just before a letting, to make a hurried inspection of a region, the soil, the rocks, the whole structure of which are probably entirely new to them, and we shall perceive sufficient reasons why the average rate of their biddings must exceed what it would be if they had better knowledge. I would respectfully point out, that engineers have it in their power, in almost every instance, by undertaking a previous exploration, made methodically, and in accordance with Geological principles, to impart such information to contractors, as would procure from them much more economical prices for their work, and insure for them in return a fair remuneration for their toil, with a greatly reduced amount of risk in fulfilling their contracts. It is palpably unwise to pay, as the public now does, a premium—sometimes a very exorbitant one—to cover risks which a little research would often remove, and which, too generally, have their only origin in the inexperience of the contractor.

FOURTH ANNUAL REPORT

ON THE

GEOLOGICAL SURVEY

OF THE

STATE OF PENNSYLVANIA:

BY HENRY D. ROGERS, *State Geologist.*

Printed by order of the Senate, February 8, 1840.

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1840.

SECRETARY'S OFFICE, Feb. 8, 1840.

Honorable Wm. T. Rogers, Speaker of the Senate.

SIR, I have received the fourth Annual Report of the State Geologist, and have on this day transmitted the same to the House of Representatives, in compliance with the Acts of Assembly upon the subject of a Geological Survey of the State.

I am yours, respectfully,

F. R. SHUNK,

Secretary of Commonwealth.

To the Senate of the Commonwealth of Pennsylvania:

In submitting herewith my Annual Report on the Geological Survey to the Legislature, I avail myself of the opportunity to offer a brief statement of the degree of forwardness of the work and the prospect of its early and satisfactory completion.

Though the several acts of the Legislature, making appropriations for the prosecution of the Survey, to continue in force for five years from the commencement, specify no period within which the investigation shall terminate, yet it has been my earnest wish and effort from the beginning to complete the survey as nearly as practicable, in the time to which the present appropriation is limited. I am happy that the advanced condition of the several branches of the work authorize my expressing to the Legislature my confident hope of bringing to a successful close all our researches in the field, by the expiration of the five years mentioned, ending the 1st of April, 1841. I beg leave also to mention my anticipation of being able, during an extra season of six months, with a much diminished scale of appropriation, giving me the aid of a portion of my present corps of assistants, to arrange and bring forward the extensive body of detailed results of the survey in a properly methodized shape. This period of six months will, it is hoped, suffice for the production of my final Report, the completion of the Geological Map of the State, and numerous illustrative drawings, together with an extensive train of chemical analysis of our ores, &c. now going on, and also for the organization of the Geological Cabinet, which will amount, it is believed, to between six and seven thousand specimens.

My present Annual Report, the first in which I have entered into a detailed description of our mineral resources, will, it is hoped, shew the practical direction and bearing of the Survey in all its departments, and by its size, (two hundred and fifty pages,) make manifest the necessity of the six months asked, for the production, in a digested form, of my final Report, embracing all the minutiæ of the Survey from the beginning.

With sentiments of great respect,

HENRY D. ROGERS,

State Geologist.

REPORT, &c.

To the Secretary of the Commonwealth.

Sir:—I beg leave to submit to the Legislature, through you, in accordance with my instructions, the following Report of the operations of the Geological Survey of the State, during the past year. In doing this, I shall confine myself, as heretofore, to a statement of the progress which has been made in the several departments of the Survey, and to a general account of the structure and resources of the different districts which have been explored, introducing only such details as are likely to be intelligible, without the aids and illustrations intended to accompany the final minute and systematic description of our Geology. Those illustrations will comprehend the Geological Maps of the entire State and of some of its more intricate regions, the numerous sections designed to exhibit the stratification and position of the mineral deposites in each formation, and an extensive series of detailed chemical analysis, intended to show the true composition and relative economical value of the numerous ores, coals, limestones, cements, clays, building materials, mineral waters, &c. collected in the progress of the exploration.

The active field operations of the Survey were commenced about the middle of April. Pursuing the system of investigation adopted at the commencement of the previous season, examinations were carried on in five of the six districts, into which for convenience sake, as mentioned in my last Annual Report, the State had been divided.

Those members of the corps engaged in exploration, embracing nine Geological Assistants; were distributed over these several divisions in the following manner.

The First district, including all that part of the State lying south and east of the Kittatinny valley, was allotted to Messrs. Holl and Trego; the former aiding me in the exploration of Bucks, Philadelphia, Montgomery, Delaware, and Chester counties, and the southern townships of Lancaster; the latter in the whole of York, and Adams.

In the Second district, comprising the north-eastern half of the Appalachian region of the State, including all the country between the South mountain and the Allegheny mountain, and between the Delaware and Susquehanna rivers, terminating on the latter at Muncy creek, I was assisted by Messrs. Whepley and Leslie, the investigations embracing many points of intricacy, particularly in the Pottsville coal basin and the valley north of the Blue mountain.

The task of constructing a detailed map and sections, intended to exhibit, when completed, all the anthracite coal fields of the State, calling for a minute examination of the topography, and an exact tracing, as far as practicable, of every recognizable seam of coal, constituted an important part of the seasons's operations in this district. The resignation of Mr. Whelpley, about the first of July, somewhat retarded the investigations essential to a thorough acquaintance with the highly complicated features and vast mineral resources of these extensive coal fields; nevertheless, I entertain a confident hope of being able to bring this part, together with the rest of the Survey, to a satisfactory termination, in two more seasons, at farthest—furnishing a map and numerous drawings, calculated, it is believed, to prove highly useful to all those in any way interested in the development of the mineral treasures of the region.

In the Third geologicial district, or that which constitutes the south-western half of the Appalachian region, lying between the Susquehanna river and the southern line of the State, and between the South mountain and the Allegheny mountain, and embracing numerous productive deposits of iron ore and other minerals, together with a valuable coal field, the explorations have been vigorously prosecuted. The detailed examination of the Cumberland Valley and its bounding ridges, devolved upon Mr. Trego, while the exploration of Mifflin, Huntingdon and Bedford counties, together with parts of Union and Centre, was divided between Messrs. M'Kinley, Henderson and Jackson. Mr. M'Kinley devoted himself to a central belt including the Seven mountains, part of Kishacoquillas valley, the whole of Stone valley, and the valleys and ridges from the eastern base of Sideling Hill to Tussey's mountains, closing his operations among the coal seams of Broad Top mountain. The termination of the season, prevented our advancing further towards the south-west. Dr. Henderson gave his attention to the belt of country south east of the last, including the greater part of Mifflin county, and the eastern townships of Huntingdon and Bedford, lying between Sideling Hill and the Tuscarora and Cove mountain. Dr. Jackson took the western portion of the district, comprehending the country situated between Tussey's mountain, and the base of the Allegheny mountain, terminating his operations for the season in the vicinity of Bedford.

In the Fourth district, embracing that part of the State which lies between the eastern base of the Allegheny mountain and the summit of Chesnut Ridge, or the western Laurel Hill, and between the Southern State line and the Bellefonte and Brookeville turnpike, no explorations were undertaken. A laborious and tolerably minute reconnoisance of this wooded region had been made during the previous season, and it was deemed advisable to postpone the examination of its somewhat obscurely developed coal fields until a greater degree of progress should have been made, in ascertaining the true relative situation of the coal seams, beds of iron ore and mineral deposites generally, in other parts of the same great bituminous coal formation throughout the more open country, lying further to the west. By adopting this order of research, making the better known geology of the vallies of the Monongahela and Allegheny, the key, which it truly is, to the at present, more obscure resources of the district in question, I conceive that the temporary pause in the examination of this district will be productive of increased accuracy in the knowledge we shall acquire of its mineral deposites, and tend materially to expediate this portion of the survey. It is proposed to resume the investigations in this district during the ensuing season with increased facilities for research.

The Fifth district, comprehending all that part of the State lying west of Chesnut Ridge, and the eastern boundary of Armstrong and Venango counties, was entrusted to Messrs. M'Kinney and Ward, who assisted in the exploration of Venango, Armstrong, Butler and a large part of Mercer and Beaver counties, and who were likewise employed in collecting a mass of minute and valuable information along a line of country extending from the base of Chesnut Ridge, through parts of Westmoreland and Washington counties, to the Ohio river at Wellsburg. A detailed section was surveyed along the tract here alluded to, commencing on the turnpike east of Mount Pleasant, following afterwards the Big Sewickly creek to its mouth, and thence crossing from the Youghiogheny to the Monongahela above Williamsport, and following the latter river to the mouth of Mingo creek, and this stream to its source. Beyond this, its direction was north of west through Cannonsburg to Cross creek, and down this stream to the State line and across to Wellsburg. The examinations made along the line here traced, being instituted for the purpose of ascertaining the true positions relatively to each other and to the surface of the adjacent country of all the accessible coal seams and other useful mineral deposits between Chesnut Ridge and the Ohio river, were performed with the aid of instruments designed to impart to the results as great a degree of accuracy as practicable. The elevation of each seam of coal, and the intervals between them, were ascertained for a great number of places along the line of this section by a barometer and barometric thermometer, both of superior accuracy, while the distances between the stations of observation were measured after the usual manner, by the chain and compass. The extensive measurements thus made, enable us to calculate by the information they afford respecting the true dip of the strata, and the undulations of the surface, the depth for any particular spot, along the line of section and over a considerable extent of adjacent country, of every important bed, even when it lies buried under several hundred feet of other strata. By availing ourselves of the data thus collected and instituting when necessary, other similar instrumental measurements across the out crop of the rocks which compose the western counties, we shall give it is hoped to the exploration of the fifth or western district of the State, during the approaching season, as high a degree of accuracy as can be deemed essential for all useful purposes. Pursuing the plan of research thus commenced, it is believed that the coming season will not only bring to light every useful mineral band in the formation, however unimportant its thickness, whether coal, iron ore, limestone, fire clay or sandstone, but determine with sufficient precision its situation below the surface throughout the whole of the wide region referred to.

In the examination of the Sixth district, which includes the wild and wooded country bounded on the north by the northern line of the State, and on the south by the base of the Allegheny mountain and the Bellefonte and Brookville turnpike, I was aided by Messrs. Hodge and Stone, the latter gentleman, though not a member of the corps, contributing his services as a volunteer for seven months in a remarkably arduous campaign with considerable advantage to the progress of the survey. Owing to the wilderness condition of much of this northern district, it was found indispensable to use a tent, and to aid our operations by employing two men in the duties incident to a camp life.

The business of these persons was to transport provisions, together with the tent and instruments, either on their backs, when it was necessary, as it most frequently was, or with the aid of a pack horse, wherever there was a road. In a region, the geology and geography of which was very imperfectly known, no systematic course of investigation could be pursued, until a certain amount of information was previously collected concerning its local and general features. After an arduous reconnoisance, it was discovered that the coal measures, the principal object of interest in this district, do not form, according to the common belief, one general basin, embracing all the high grounds north of the Allegheny mountain; but occur in a series of small, separate coal fields, confined to the most elevated portions of the region. This important fact being determined, a clue to the position of the coal was soon acquired; saving much labor and time in our subsequent researches. It was soon seen which belts of country demanded a minute investigation, and which authorized a less laborious study. Wherever openings into the coal had been already instituted, or where new ones could be undertaken by ourselves, without too great an expenditure of time, every effort was made to ascertain, as accurately as possible, the number, thickness, and quality of the coal seams, and the order of their superposition. In the wilder tracts of the country, wherever previous research had proved the possibility of the occurrence of the coal measures, a minute inspection of the ground was made; and if any tokens of the existence of a coal bed were noticed, either in the character of the rocks, or in the discovery of the coal slate and smut in the channels of the brooks or in the upturned roots of fallen trees, regular diggings were undertaken, and the position of the coal bed proved. In this way, several seams, hitherto unknown, were developed; and it is believed no important deposite within the region has been passed over undiscovered. That portion of Lycoming county north of the Susquehanna river, between Farrandsville and the Loyalsock, with the exception of a small district bordering this creek—also, the whole of Tioga county, and that part of Clinton county lying on the Tangascootack—have been in this manner examined, with as close a degree of scrutiny as was compatible with the nature of the country, or usual in researches of this sort. Only a few additional researches, of a general character, remain to be made. A revision of certain parts of the tract thus explored will, it is hoped, establish the true situation of some of the smaller beds found in a few places, about which some uncertainty still prevails, and enable us to complete those observations of the topography requisite to the proper construction of the geological map.

Distributing the investigations in the several districts among the different members of the corps after the manner thus specified, my own duties consisted in superintending the operations in each quarter, either in regular rotation, or in such order as the intricacies and difficulties of the research made most desirable. Directing, and personally sharing in, the operations of the Survey in each district, I am enabled by the above organization to satisfy myself of the accuracy of the observations reported to me, and to contribute, at the same time, my own examinations in aid of those of my assistants in all cases of doubt and difficulty, and to concentrate, if necessary, an extra amount of aid to points which, from their importance and intricacy, require instrumental measurements, or much detailed research.

By adopting the mode thus briefly sketched, and retaining the present organization in the several departments of the Survey, I hope, as each individual in the Survey has now acquired a familiarity with the peculiar structure and local features of the particular district which has been assigned to him, and with the nature of the difficulties to be overcome, to be able to complete nearly the whole of the field investigations, by the close of the next season, leaving but few tracts in the State, of any geological interest, unexplored.

In stating to the Legislature the prospect of so early a completion of the operations in the field, I deem it my duty, at the same time, to mention that an additional season, but probably not an entire year, will be required for finishing various branches of the Survey unavoidably delayed by the active and engrossing duties hitherto essential to the progress of the exploration. For the purpose of revising many intricate portions of the work, where a clue to the stratification has been discovered during the subsequent examinations made in neighboring tracts, and for conducting a number of measurements necessary to the settlement of important practical points remaining still in doubt, this final season will be important. It will be indeed indispensable for the production of the general final Report, and for completing the geological map of the State, and the local maps and geological sections intended to exhibit the situation of the mineral deposites of each district, and for finishing the analysis of a vast number of ores, coals, and other useful substances, collected during the prosecution of our researches.

In the chemical department of the Survey, the analytical operations have been vigorously prosecuted. The Chemical Assistant, Dr. Robert E. Rogers, and Martin H. Boye, having been enabled, by improved arrangements in the labortary, to perform an extensive series of valuable analysis, disclosing the chemical composition of many of our ores, coals limestones, and other useful substances, and developing a number of important facts connected with their practical applications in the arts. It is believed, that by the end of the autumn of 1841, contemporaneously with the proposed close of the other departments of the Survey, the chemical work, conducted as at present, will have made known the nature of every material, of any value, within the State, and shown its adaptation to useful purposes. The detailed analysis will, in all, amount to several hundred. By affixing to each specimen examined, a record of its chemical composition, and by placing it in the State cabinet, at Harrisburg, the value of the collection will be greatly enhanced for all purposes.

The specimens collected for the State cabinet during the past year comprising a large body of ores, coals, limestones, cements and other minerals, occupy one hundred and thirty boxes and amount in all to about three thousand pieces. The whole body of specimens hitherto collected during the survey may be estimated at about eight thousand, about four thousand of which, form the contribution hitherto made towards the general State cabinet, which is hoped will ultimately amount to six or seven thousand, and embrace every thing appertaining to our geology and our mineral wealth. The specimens thus far gathered have been opened and temporarily classified and arranged for the purpose of having them as accessible as possible, both for analysis and for reference while framing the annual and final reports on the survey. Upon the termination of the field work, when the collection shall be completed, the requisite analysis performed, and the final report prepared for the press, the whole will be conveyed to Harrisburg, where it is intended permanently to place it for the use of the public. Until then, little advantage, it is conceived, would arise from depositing the specimens in the State Capitol, as they would require to be re-arranged every time an addition were made to their number by the annual gathering, and as they would prove moreover, comparatively useless for reference before the appearance of the final and detailed report, inasmuch as it and the cabinet are designed mutually to elucidate each other.

Should the Geological Survey be completed in the autumn of 1841, as I confidently hope it can be, it will then have occupied five years and a half. The appropriation for the last half year need not I conceive amount to more than five thousand dollars, the operations of the final season admitting probably of such a reduction in the corps, as not to require much more than one half the present scale of expenditure.

CHAPTER I.

Sketch of the Geology and Mineralogy of those parts of the First or South-eastern district, explored during the past season, comprising Bucks, Montgomery, Philadelphia, Delaware, Chester, part of Lancaster, and the whole of York and Adams counties.

The physical feature of the south-eastern district included between the north-eastern base of the South mountains, and the eastern and southern boundries of the State, are, throughout its southern and central portions, those of a moderately undulating plain, interrupted by few abrupt elevations; while along its northern side we have a broad belt of rounded and swelling hills and ridges some of which attain considerable height.

The rocks comprehended within this extensive area belong, for the most part, to the stratified class; embracing many varieties of both primary and secondary origin. The unstratified rocks of a crystalline structure occur either in the form of small local and irregular veins, or of dykes of greater or less magnitude, intruded through the strata. They include several varieties of *granite*, *sienite* and other similarly constituted rocks, all in thin veins traversing chiefly the primary strata along the southern side of the district, and also, several species of trap rocks, the larger and longer dykes and ridges of which, range principally in the belt of country south of the South mountains and within the Red Sandstone formation. The stratified rocks of the region, occupy a succession of narrow parallel belts, which generally observe a direction from E. N. E. to W. S. W. most of which range entirely across the district from the Delaware river to Maryland. The first of these formations, beginning our enumeration on the south-east, as a broad belt, composed principally of gneiss, mica slate and talc slate and their subordinates varieties which occupy the space between the tide water and the southern margin of the great limestone valley of Chester and Montgomery counties, and its prolongation east and west. To this succeeds the interesting calcareous formation of the valley just referred to, which consists of a more or less crystalline limestone, obviously like the former rocks belonging to a primary date. To the north of the range of this limestone, there occurs, occupying some of the northern townships of Chester county, another large area of gneiss rock. With the exception of this tract, all the formations north of the line in question rank themselves in our Lower and Middle Secondary stata. Thus the sandstone which form the North Valley Hill, Mine Ridge, the Welsh mountain, Chickey's Ridge at the Susquehanna, Milbough Hill, and the hills between Reading and Allentown belong to F. I. of the Lower Secondary or Appalachian series; while the limestone of the central townships of Lancaster county, and of the interior of York county, refers itself to P. I. of the same group. The red shales and sandstones which traverse the central and northern parts of the district from the Delaware river to Maryland, constitute our middle secondary rocks. These comprise a large part of Bucks and Montgomery, the northern side of Chester near the Schuylkill, the southern townships of Berks, the northern part of Lancaster, the southern side of Lebanon and Dauphin and the northern townships of York, together with a wide tract extending through the centre of Adams.

In presenting a sketch of that large and important part of the district which has been examined during the past year, I propose adopting as far as practicable a uniform order in the description of the several formations, commencing with those on the south-eastern side and advancing successively towards the north-west. The detailed delineations of each belt, as far as this will be attempted, will in nearly every instance be pursued from the N. E. towards the S. W. or longitudinally with the general course of the rocks.

SECTION I.

Gneiss and Mica Slate, with their associated Rocks and Minerals.

The first or south-eastern division of the primary stratified rocks, comprehending the gneiss, mica slate and talc slates situated south of the limestone valley of Montgomery and Chester counties, commences in New Jersey, in a narrow point about six miles to the E. N. E. of Trenton, expanding gradually in its course towards the W. S. W. until it forms a broad belt occupying the whole of the southern townships of Chester, Lancaster and York, where it leaves our State and passes into Maryland. The south-eastern margin of the formation crosses the Delaware at Trenton, where it is well exposed, forming the falls of the river. In this vicinity it consists chiefly of a dark hornblendic gneiss, dipping at a rather steep angle to the S. S. E. Along its course for several miles south-westward, a deep covering of diluvium, conceals a large portion of the belt, and precludes our discovering its local features.

Crossing the Neshaminy about a fourth of a mile south of the road leading from Attleboro to the Buck tavern, in Southampton township, occurs the most eastern exposure of the primary limestone in this quarter of the State. It is in the form of a small oval or lenticular bed, occupying an area not exceeding one half an acre, upon the farm of Mr. Van Arsdale. The bed corresponds in its dip and direction with the strata which surround it. A dyke consisting, chiefly of *Labrador Felspar*, has been protruded through it, and seems to have altered its structure, producing in it, near the line of contact, several minerals, usually foreign to the composition of limestones of this character, such as *graphite* (or *black lead*), *tabular spar*, and *oxide of titanium*, *Actinolite* and *augite*. North-east of the Buck tavern, occurs a dyke of close gained trap. Rather more than a mile south of the Buck tavern, on the banks of the north branch of the Paquasin creek, there is a locality where Plumbago, or black lead, was formerly worked, but the place is abandoned, and the pit filled up. Near the bridge at Rockville, a granite vein is seen; and in the creek, the gneiss contains several minerals, not unfrequently met with in this locality. Among these are *zircon*, *crystallized oxide of iron*, *dark green*, *mica* and *blue quartz*. Where the road from Davisville to Huntingdon intersects the county line, there is an extensive *trap dyke*, running nearly east and west, in a straight line; for three miles. The gneiss in its vicinity assumes very much the character of a sienite, and promises, in some places, to be useful as a building stone. A little to the south of this, we encounter the southeastern extremity of a narrow belt of a somewhat peculiar rock, consisting chiefly of felspar, which takes a W. N. W. direction across the old York road, about a fourth of a mile north of Willow Grove, and afterwards conceals itself beneath the overlaying middle, secondary red sand stone. *Zircon*, *titanium*, and *oxide of iron*, are occasionally found in small quantities in the boulders of gneiss and other rocks in the neighborhood of Willow Grove. Included among the hornblendic gneiss of Trenton, and the ordinary granite gneiss and mica slate of the lower part of Bucks and Montgomery, there occurs a somewhat remarkable stratum of felspar rock, well exposed in a quarry on the west side of the Delaware. This material is applicable to several useful purposes, being much employed in Trenton as a flag and curb stone, and furnishing a material much better fitted, by its compact structure, for MacAdam roads, than the softer and more granular rocks which adjoin it. It consists, merely, of felspar and quartz, not separately crystallized, but intimately blended and interfused. It sometimes contains a little talc, together with crystals of *schorl* and *oxide of iron*. Its ordinary color is a light straw yellow. The prevailing dip of the stratum is to the S. S. E., at a steep inclination. Its course is west by south, passing north of Falsington, through Oxford, to Mather's Mill, on the Neshaminy; thence nearly westward, across the road leading northward from Smithfield; after which, entering Montgomery county, it soon begins to expand in width, becoming, when it reaches the Old York turnpike, between Abington and Willow Grove, about a mile and a half broad. About a third of a mile west of the turnpike, it separates into two portions; the northernmost, two thirds of a mile wide, passing westward along the course of Sandy run, and finally disappearing beneath the margin of the middle secondary red sandstone; the southernmost, having a less breadth, taking a S. W. direction, and forming a ridge which skirts the limestone valley, on its south, from this point to the Schuylkill, near Spring Mill, where the stratum at last thins out. A part of this ridge, two miles N. E. of the Schuylkill, is called Barren Hill, where the peculiar rhomboidal structure sometimes seen in the rock is well exposed. In that portion of the formation which passes through Bucks county, several quarries have been opened, the rock being there capable of furnishing a tolerably good curbstone.

The greater portion of the southern and eastern sections of Philadelphia county, shows a deep covering of diluvium, concealing the gneiss and its associated rocks, except where they are exposed in the vicinity of the streams. In this part of their range, the primary strata are much traversed by veins of coarsely crystalized granite, in which the three ingredients, the *felspar*, *quartz* and *mica*, are often of unusual size, the felspar being generally by far the most predominant mineral, and exhibiting a remarkable tendency to pass to the condition of *kaolin*, by decomposition. This rotting, by atmospheric influence, is not confined to the injected veins of granite, but characterizes also a large part of the gneiss, especially in the country around Philadelphia, where the rocks are sometimes in a decayed and pulverulent condition to a depth of more than twenty feet. Advantage is occasionally taken of this circumstance, the loose materials of the rock being sifted to procure a sand which is of remarkable sharpness, and well suited for the purposes of masonry.

At Fairmount, near Philadelphia, the gneiss projects above the diluvium, and is quarried to some extent in this vicinity, and also on the west bank of the river, at Judge Peters's. The grain, or lamination of the rock, is exceedingly contorted; implying the occurrence, at one time, of an immense compressing force. In all the quarries from Fairmount to the Falls of Schuylkill, the rock is intersected by numerous cross joints, which appear, until closely examined, to represent its divisional plains or true stratafications, and which at Fairmount are nearly horizontal. These joints divide the mass into blocks of convenient shape and dimensions; and when they dip in the right direction, greatly facilitate the operations of the quarry. The belt of gray granitic gneiss which passes Philadelphia, is well developed on Darby creek, Crum creek, Ridley creek, Chester creek, and the other adjacent streams. On nearly all of these, it has long been wrought, supplying Philadelphia, and other places, with a large amount of very excellent curbing stone, and material for the foundations of houses and for other purposes. At the Falls of Schuylkill, there is a large quarry of very excellent gneiss, of a light gray aspect, which has long contributed its supply of good building material to Philadelphia. In this quarry is a vein of large grained granite, with red felspar; the strata dip to the N. W. Higher up the Schuylkill, the relative proportion of the felspar in the rock is less, while the amount of mica is greatly augmented. Nearly the whole distance from Fairmount to Manayunk, the prevailing dip of the rocks is towards the north, with only occasional irregularities. Approaching the mouth of the Wissahiccon, *garnets* begin to be abundant; and the rock assumes, for considerable spaces, the composition of a true mica slate. *Staurotide*, *cyanite*, and *red oxide of titanium*, with other minerals, occur in this vicinity.

Near Manayunk the predominant rock is a mica slate. It is much contorted and abounds here and for two miles up the river, as far as the soap-stone quarry in regularly formed crystals of garnet. It is also intersected by numerous veins of coarse *felspathic granite*.

At the tunnel on the Reading rail road, and near the Flat Rock bridge a belt of considerable width crosses the river north of which the mica slate is again repeated, embracing between this point and the belt of soap-stone, one or two smaller zones of the hornblendic rock.

The so called, *soap-stone rock* referred to, crosses the Schuylkill about a mile and a half above the Flat Rock bridge. Its average width is a little more than a furlong. This stratum includes two distinct bands, that on the south being mineralogically a rather peculiar rock, consisting of *steatite* and *talc*, imbedding numerous lumps or knots of dark *serpentine*, while that on the north, is a dark variety of *serpentine* holding occasionally crystals of hornblend. The *steatitic rock* has been quarried for many years on the east bank of the river, supplying Philadelphia to a moderate amount, with a material excellently adapted for the lining of furnaces, grates and fire places. Until the general introduction of marble, it was also used to some extent for the steps of houses, for which, however, it is not so well adapted, the soft steatite being easily worn and leaving in course of time the harder nots of serpentine to roughen the surface.

The steatite and serpentine belt first shows itself near the foot of Chesnut Hill, three fourths of a mile east of the Germantown turnpike. Increasing in width, it crosses the Wissahiccon a short distance below the intersection of the same road where it is well exposed. At this locality it contains *green mica. talc, steatite, dolomite, serpentine* &c. in abundance. On the Ridge road, a few detached fragments, in the soil of the neighboring fields, are all that can be found to indicate its course. Approaching the Schuylkill, the *serpentine band* augments considerably in width, forming a distinct ridge which extends into Lower Merion township. At the soapstone quarry on the Schuylkill, the dip of the steatitic rock, appears to be parallel with that of the mica slate lying south of it, but it is so much intersected by cross joints as to render it difficult to determine this point with certainty. Between the steatitic rock and mica slate there occasionally occurs a thin band having nearly the composition of a chlorito slate. *Crystallized dolomite, carbonate of lime* and *talc*, occur here abundantly. About half a mile west of the Schuylkill in Lower Merion township, there is another quarry which has likewise been worked for many years. The steatite at this locality can be procured in larger blocks, being less intersected by joints: it frequently contains, however, concretions of *carbonate of lime, dolomite* and other minerals which deteriorate its value. About a mile and a half further west, the belt expands to nearly half a mile in width, separating soon into two portions, which cross Mill creek about three furlongs asunder, and then thin out. The serpentine throughout the whole range, maintains nearly the same features, being much mixed with heterogenious minerals. No distinct line of division separates it from the steatite on its south. North of the serpentine range the gneiss again appears, traversed as usual, by veins of granite. Further north, the character of the rock is entirely changed, it having hardly the aspect of a crystalline or primary stratum. This bed is traceable from the river to the Bethlehem turnpike. On the west side of the Schuylkill, it forms a high ridge, dividing the gneiss and mica slates on the south, and the talc slate and limestone on the north. Not far west of the river *hematitic iron* ore exists near it, though not in large deposites, and on the Gulf road ore was worked for some time. Traces of iron ore are frequent in this part of the formation.

Not far from Bellemont the beds of hornblendic gneiss and mica-slate contain much injected granite passing to the state of *kaolin*; one vein of which is from twelve to fifteen feet in thickness. On the Lancaster turnpike about four miles from Philadelphia, there is a locality where it is thought the gneiss might be profitably worked; it was exposed in cutting the new rail road. In the northern part of Blockley township, the hornblendic variety of the gneiss is quite abundant. The townships of Lower Merion, Haverford, Maple, and also the south of Radnor, are composed chiefly of mica slate. In Upper and Lower Providence, Springfield, Darby, Upper Darby, and in Ridley townships, gneiss and mica slate mostly prevail. In the northern part of Lower Merion and Radnor, there is a similar rock to that on the Schuylkill above the serpentine band. It becomes talcose towards Tredyffrin.

On the road from Chester to West Chester, through Edgemont, about three miles from the former place, the beds assume a scientific aspect, a circumstance which is not unfrequent. Its structure implies rather a *metamorphic* than an *igneous* origin. Gneiss and mica slate through which extensive trap dykes have been protruded, are often modified into a rock of similar character.

Near the Blue Hill school house in Upper Providence township, there is a small bed of serpentine, and at the cross roads in Middletown townships, rather more than a mile from Wrangletown, *jasper*, *calcedony*, *flint*, *hematite*, *steatite*, and other minerals occur in the serpentine formation which appears to constitute the hill which crosses the Chester and West Chester road diagonically from S. W. to N. E. The trap dykes that occur in Delaware county are mostly small and rarely influence the strata in their vicinity. One of some size occurs in Newtown.

Near the Spread Eagle, on the Lancaster turnpike, fourteen miles from Philadelphia, there exists a small included bed of serpentine, a little to the north of the main road. No exposures of the rock are visable, but it is distinctly marked by its sterile soil which has caused it to be abandoned by the agriculturist. On the north of this lies the talc slate, which passes so gradually into the mica slate on its southren margin as to render it impossible, unless in particular instances to delineate them separately. The upper or northern margin of the talc slate belt, bounding the primary limestone on the south, is distinctly marked, being generally near the base of the South Valley Hill. This band of primary slates pursuing a W. S. W. direction in the range of hills south of the Great Valley, expands from a width of one mile at its eastern extremity, to a breadth of several miles as it approaches the Susquehanna.

Another bed of serpentine, similar to that near the Spread Eagle, occurs in the mica slates about a mile and a half S. W. of the Paoli, and about one-third of a mile further on in the same direction, there is a large bed of the same rock, nearly two miles in length, which crosses the road from Saugartown to the Warren tavern, and thins out in East Goshen, not far from the township line. North of Saugartown, it has been quarried, furnishing the material for the monument commemorating the massacre of Paoli. In the same range another included bed of the serpentine crosses the road leading from the General Green, to the Steamboat taverns. It is a mile and a half in length, and nearly a fourth of a mile wide. The rock at this locality contains *talc*, *asbestos*, *magnetic iron ore*, *steatite*, and *quartz* and in smaller granules, *amethyst*, *jasper*, *garnet*, *actinolite* and *schorl*. Another and smaller band occurs in a direct line with it, about a mile further west, thinning out at Taylor's mill on York run, where it has been quarried to some extent, supplying the building material for the Episcopal church in West Chester.

Serpentine has generally been ranked by geologists among the unstratified, igneous rocks, few instances being recorded where it assumes a regularly bedded structure; but in the belts above described, there is little, either in its relative position to the adjacent strata, or in the appearance of the rock itself, which imply that it has been intruded in a melted state. Its aspect is that of a strictly laminated rock, the divisional plains conforming to the stratification of the surrounding mica slate. This is particularly conspicuous at the quarry last alluded to. We perceive, moreover, no evidence of any contortion in the neighboring schistose rocks, such as would indicate the protrusion of this material. The mica slates, and included serpentine, all dip at a high angle, towards the S. S. E. In the township of West Goshen, occur *carbonate of magnesia*, *magnesite*, several varieties of *quartz*, *cyanite*, *staurotide*, *asbestos*, *amyanthus*, *steatite*, *talc*, and *octohedral crystals of iron*, at several localities, but generally in small quantities. In East Bradford township, a few furlongs west of the forks of the Brandywine, we meet with another bed of serpentine, somewhat more than a mile in length. It is exposed on the road leading from West Chester to Wistar's bridge. Near Strode's mill, there occurs another bed, apparently a portion of a different belt. About two miles north of the forks of the creek, on the road leading from Wistar's bridge to the Gap road, we pass a barren hill, which consists of serpentine; and another tract similar occurs on the road from Marshallton to Trimble's mill.

On the Fork run, a mile and a quarter from its juncture with the Brandywine, exists a small lenticular bed of *limestone*, included among the layers of the mica slate. It does not exceed half an acre in extent; but it is a useful locality, furnishing lime for the neighboring lands. In East Bradford township, besides most of the minerals found in West Goshen, we find *fœtid carbonate of lime*, *amethyst*, *zircon*, *brown tourmaline*, *adularia*, *actynolite*, *steatite*, and *lithomarge*. The dip of the rocks on the Brandywine, both in the talc slates and mica slates, is precisely the reverse of that which they display on the Schuylkill, being generally S. S. E., at a steep angle.

Referring in the next place to some points in the geology of the district, south of West Chester and east of the Brandywine, we may mention the occurrence of an excellent *brickmaker's clay* worked in the vicinity of that town and at several other places. In Birmingham township, on the farm of Caleb Brinton, one mile west of Dillworthstown, the mica slate contains a small interposed bed of limestone, occupying about one acre. It is quarried, yielding a rock of a coarsely crystalline structure, which produces a very good lime. Some distance south of Dillworthstown, a narrow vein of a superior white felspar crosses the road leading to Wilmington, from which masses of considerable size and purity are obtained. Still further to the south, on the farm of Thomas Bullock, in Delaware county, we find another bed of limestone, somewhat similar to the last, though yielding a material of rather less purity. West of the Brandywine, we find the small lenticular *beds of limestone* becoming more numerous among the primary slates. On the farm of William Harvey, one mile above Chad's Ford, is a fine white limestone, containing crystals of *Brucite*. Another bed is quarried about two miles west of the creek, near the Pennsborough township line. It is somewhat larger than any previously described, and lies in the bottom of a valley. The rock is large grained, partly white and partly speckled by dark mica, or clouded by a little carbon. The bed, and the adjoining strata, dip to the south. According to Mr. Townsend, of West Chester, about four hundred and eighty perches of limestone were quarried in this township during the year 1838. Chrome ore, though only in small quantity, has been found on the farm of Joel Swain. *Arragonite, crystallized augite, sahlite*, and *sphene* crystallized in augite, were also found in this township. In the adjoining township of Kennet, about thirteen hundred perches are said to have been procured from the quarries of Caleb S. Jackson and Lewis Ganser; the former situated on Red Clay creek, three-fourths of a mile below Marshall's mill; the other on the Delaware line, on a smaller branch on the same stream. The rock, especially at the latter locality, is coarsely crystalline. At both places it is white, and contains *carbonate of magnesia*.

Another small lenticular bed of limestone is traceable near the meeting house at Kennett's Square, but it is not quarried. A fourth bed, of the same description, crosses the western line of Kennett township, about one mile south of the village. A large quarry exists here, on the farm of J. M. Phillips, the stone yielding an excellent lime. The dip, in all these instances, is towards a point a few degrees east of south. Two narrow bands of limestone, about a furlong apart, occur not far from Barclay's mill, higher up on the same stream. The northern and largest one consists of a firm, white and sometimes bluish limestone, containing carbonate of magnesia. These beds are somewhat contorted. On the farm of Thomas Webb, in this neighborhood, a small body of *chrome ore* has been discovered, several tons only of which have been dug. A large limestone quarry has been opened on the farm of Mr. Logan. It yields a good lime. In East Marlborough township, several interesting minerals were met with. Among these are *zircon*, *basanite*, *fœtid felspar*, *beryl*, *epidote*, *tremolite*, and *dialage*, all occurring near Unionville; also, *chromate of iron*, *oxide of titanum*, *iserine*, *spongiform quartz*, &c. in other places. During twelve months, about seventeen hundred and twenty perches of limestone were quarried in this township. In West Bradford township, on the Brandywine creek, near Woodwards's mill, the slates enclose a bed of limestone; and in the same range, to the W. S. W. of this, there exists another larger one, which thins out in crossing the road from Downingstown to Marshallton, one mile north of the latter place. Limestone is also quarried near the Poor House, not far from the southern line of the township, where an excellent lime is produced. At this locality, we find *fœtid quartz*. Another small band of limestone, occupying perhaps a fourth of an acre, may be seen a little north of this, on the road to Marshallton. During twelve months, about four thousand perches of limestone were quarried in this township.. A dyke of fine grained trap crosses the country east of Marshallton, in a S.S.W. and N. N. E. direction, forming a ridge of rather good soil.

In Newlin township, about five hundred perches of limestone have been raised in one year. This township is rich in a variety of minerals; among which we may enumerate, *precious garnet* in small quantities, *radiated quartz*, *chalcedony*, *agate*, *corundum* (both massive and crystallized), *green tourmaline*, *beryl*, and *sapphire ligeforum*, *asbestos*, *oxide of titanium*, *&c.*

In East Fallowfield township, near Laurel Forge, occurs a steatite rock, at one time quarried, but now only occasionally wrought. Serpentine, also, occurs on the road leading from Marshallton to Coatsville, near the intersection of a small stream entering the west branch of the Brandywine, a little below the paper mill. Nearly the whole of this township consists of the talc slate formation, which crosses the east branch of the Brandywine above the mouth of Valley creek, and passes through the northern part of West Bradford, and thence expands in width through East Fallowfield into West Fallowfield, where the proportion of mica slate in the rock becomes considerable. On Doe run, in the latter township, there is a large quarry of excellent limestone, near the cotton factory. Though nearly in a line with the bed at Phillips's mill, one-third of a mile distant, it does not appear to be the same. In both instances, the dip is towards the south. The rock is bluish and white. Much limestone exists in this vicinity; and from indications, the beds are probably of some extent, though imperfectly exposed. In West Marlborough, the adjoining township, to the south, about eight hundred and fifty perches of limestone are quarried annually, obtained chiefly on Doe run. About a mile and a half north of Londongrove Meeting House, there is a bed of white limestone, containing in some abundance, a mineral, the nature of which we have not yet determined. Among the minerals found in West Marlborough are dolomite, fluate of lime, magnesite, scapolite, radiated, crystallized and fibrous tremolite, &c. Limestone occurs in the southern part of the township, on the farm of William Penix, two miles to the north of Chatham. It has received but little attention. About half a mile south of Londongrove Meeting House, there is a small hill, consisting of a sandstone, referable, apparantly, to F. I. of the lower, secondary series. The rock dips to the S. E. and seems to be a small patch of that formation which has escaped denudation. Another hill of the same sandstone crosses the Wilmington and Lancaster turnpike, a little south of Chatham. In this latter tract, which is about a mile long and a fourth of a mile wide, the sandstone dips at an angle of forty-five degrees, to a point a little east of south. The occurrence of F. I. in this insulated position, so far to the south of its general margin, which is along the northern side of the Big Limestone valley, is somewhat remarkable, and implies how extensive was the denudation which removed the lower, secondary strata from the southern belt of the State, which they appear, in part at least, to have covered. Near Chatham, *asparagus stone (phosphate of lime)* may occasionally be found, and *oxide of titanium* more frequently. During 1838, the limestone quarried in this township amounted to fourteen thousand six hundred and eighty-four perches. A bed, crossing near the branch of White Clay creek, half a mile from Chatham, is extensively quarried. The prevailing color of the rock is blue, though occasionally it is white. It yields an excellent lime, and appears to cover a considerable area. About a mile south, a bed of the limestone occurs, immediately on the creek at Stephen's mill. It is small, and has not been much worked. Steatite rock exists in the same neighborhood. One mile south of Chatham, there is a small quarry of limestone, of a blue color, on the farm of William Hicks. Fine specimens of *ivory quartz* occur in this locality. A white, and sometimes brownish, granular limestone, often disintegrated, is seen on the farm of Phœbe Morgan, half a mile north of Westgrove Meeting House. A quarry of fine limestone lies further down the stream, near Jackson's mill; and a large quarry on the east branch of White Clay creek, near Avondale. The beds here are thick; the rock close grained, and advantageously wrought, and of a bluish and white color, affording, when burnt, a good lime. Potter's clay abounds in this township; also, a little *iron ore*, and crystallized *red oxide of titanium*. In New Garden township, limestone occurs in several localities. One on the eastern township line, belonging to J. M. Phillips, has been already mentioned. Elfric Wilson has opened one on the road from the Londongrove Meeting House to the Friends' Meeting House, on the Wilmington turnpike, in New Garden. It is situated in a valley not far from the northern line, on the west side of the road. A very good stone is raised at this quarry, which is of a blue and white color. The beds dip to the south, at a steep angle. Dochranamon Hill consists chiefly of sienitic rock and mica slate, the latter being sometimes quarried for flag stones. Some of the gneiss in this vicinity furnishes a good building stone. A narrow belt of limestone, yielding a tolerably good lime, is quarried about three-fourths of a mile south of the above mentioned hill. A bed of rather pure *kaolin*, from which several hundred tons have been procured, occurs on the farm of Samuel Hoopes, in the southern part of the township. It appears to be abundant, but the demand for the article is limited. In this neighborhood occurs *magnesian garnet*. About three-fourths of a mile from the Delaware State line, a bed of limestone was quarried on the farm of Thomas Brown. A section in the quarry shows the limestone in a nearly horizontal position, regularly overlaid by mica slate. It is granular, and liable to disintegrate.

Half a mile lower down on the same stream, a branch of White Clay creek, there exists a bed of impure micaceous limestone; quarried on the farm of Septimus Evans. Some parts of the quarry, however, afford a good material. The Waste Land quarries, so called, in this vicinity; are not much worked—the beds have the usual S. E. dip. A part of the rock is inclined to disintegrate, though the quality of the lime is rather good. The quantity of limestone quarried in this township in twelve months was upwards of two hundred and sixty thousand perches.

In London Britain township, there is an extensive belt of limestone. The rock is bluish and white, lying in thick beds. It is compact and produces a good lime. The whole yields from several adjoining quarries, seventeen thousand perches per annum.

Gneiss and mica slates traversed by occasional belts of hornblendic and sienitic stratified rock occupy the townships of London Britain, New London and the greater parts of East and West Nottingham, Upper and Lower Oxford, Londonderry, &c. The soil in some places is moderately fertile, but when the talc and mica slates prevail, and they constitute the predominate formation, it is not productive. In Londongrove near Morris's mill, a singular hornblendic rock occurs which might pass for a variety or sienite. Near Brown's mill, on Little Elk creek, in East Nottingham, we find the eastern extremity of that broad belt of serpentine rock known as the Pine Barren range. The southern margin crosses North-east creek between the cotton factories and the Maryland line. The northern margin passes almost due westward near Kirk's mill to Carter's mill, on the Octarora creek and thence to the Maryland line, at its intersection with the Conawingo. Chrome ore is found in small quantities in this belt not far from Ramsey's tavern, but not in abundance. It also occurs though not in quantity a mile and a half east of the tavern near a small brook which crosses the state road. By washing the debris which strews the bottom and margin of this stream—much chrome ore in a granular form is collected. Two excavations have been opened for the ore in the Pine Barren at Carter's mill, in West Nottingham, but the mineral was soon exhausted. In this township, during the year 1838, one hundred and fifty tons of chrome ore were procured and about fifty tons in East Nottingham. Its market price is about sixteen dollars per ton.

Some of the more mottled varieties of the serpentine in the former township, are quite compact and susceptible of a polish, promising to be adapted to ornamental purposes. A short distance below Carter's mill on the Octarora, there is a seam of the *silicate of magnesia*, from which in 1838, about eight hundred tons of the mineral were procured, valued at four dollars per ton, at the quarry. It lies in the form of compact veins or lenticular beds, of no great thickness, mixed sometimes with steatite and serpentine, the quantity however, seems abundant. A little higher up the creek a narrow vein has been discovered where the mineral is intermixed with much serpentine and other substances giving it the mottled appearance of a *breccia*. The serpentine belt of this and the adjoining townships contains both steatite and asbestos, The serpentine ridge after crossing the Conewingo, and passing into Maryland, is prolonged in a W. by S. direction crossing the Susquehanna near Fraser's Point, and thence entering Harford county. Near the Octarora, not far from Wood's Fulling mill, Mr. Isaac Tyson has a large chrome pit which has been extensively worked for several years. The mineral does not occur in the form of a regular vein or load, but in bunches irregularly mingled among the serpentine on one side, but somewhat well defined on the other, having a general S. E. underlie or dip. The fragments of serpentine on the surface contain much chrome ore, and this locality promises a supply sufficient for the demand for sometime to come. Chrome ore exists also, though not abundantly, near the Baptist Meeting house, on the Maryland line, where steatite, often containing disseminated ore, occurs in great abundance. Asbestos is also common here. The indications are, that the cromiferous iron ore and other associated minerals exist in many places in the belt where they have not yet been procured.

The principal rock in the southern part of Lancaster county is talc slate. The soil resulting from this formation is generally sterile and unprofitable. On the Susquehanna river, a little above the mouth of Peter's rock, near Peach Bottom ferry, slate is quarried on both sides of the river. The strata dip toward the S. S. E. at an angle of seventy-five degrees; the lines of bedding and of cleavage coinciding. Irregular joints traverse them generally at an acute angle. The slates split with great facility.

Near Snedley's saw mill on Little Conewingo creek, occurs a small bed of serpentine embraced between strata of talc slate and mica slate, On the summit of a hill near the road, chrome ore and silicate of magnesia exist in small quantites. A pit was opened here, but is no longer worked. At the Methodist Meeting house, between Little Britain and Drumore townships, we meet with a small bed of curious felspathic rock analagous to that which bounds the primary limestone near the Schuylkill. It yields a good white clay but not in quantity sufficient to make it an object of importance.

Talc slate constitutes for the most part the rock in Colerain, Drumore, the lower part of Bart and part of Martick townships, being varied by a few occasional belts of mica slate. The soil is therefore poor and the country thinly settled. In Bart township the important limestone belt of the Great Valley thins out. On a line with this limestone is a small lenticular patch of the same rock known as Bears' quarries.

Having now completed the observations at present to be made, respecting that part of the southern primary belt which lies south of the Great Limestone valley, from the Delaware as far westward as the Susquehanna, I shall proceed in the next place to describe the primary tracts, lying north of the same valley, and between this latter river and the Schuylkill, then treat of the Geology of the Great Valley itself and afterwards extend my observations west of the Susquehenna into York county.

Gneiss North of the Great Valley of Chester county.

That part of Chester and Lancaster counties lying immediately north of the Great Limestone valley, is occupied chiefly by stratified primary rocks of the gneiss system. Much of this gneiss is of the granitoid kind, while many beds are hornblendic. The predominant constituent is felspar, though it presents a considerable variety in its composition. In Chester county, to which these observations more especially refer, it is usually rather coarsely crystalline, but in Lancaster, particularly toward the Susquehanna river, we meet with a larger relative proportion of mica and talc slate, replacing the genuine gneiss.

The junction of these gneiss rocks, with the primary limestone of the valley is concealed by the over lapping sandstone (F. I. of our lower secondary series) which forms the North Valley Hill, from the Schuylkill to the westernmost branch of the Octarara creek. On the north, the gneiss of Chester county passes beneath the middle secondary red sandstone formation from Valley Forge, to the eastern extremity of the Welsh mountain, and on the N. W. beneath the older secondary sandstone of the Welsh mountain itself. Mica and talc slates prevail in much less proportion in this tract than throughout the primary region, already described, lying south of the Limestone valley. In the parts of East Nantmeal, Vincent, Pikeland, Charleston and Uwchland, where the gneiss prevails, its character is very uniform; felspar, hornblend and quartz, being here the prevailing constituents, and mica relatively rare.

Iron ore has been dug here for several years past in several places, about five hundred tons being annually produced. In Vincent township, about six hundred tons are annually procured. It occurs at many localities east of the Yellow Springs, but no where in apparently large deposits. The composition of the ore found near the Yellow Springs, will appear from the analysis given in Chapter VI.

At Kimberton, on the farm attached to the Academy, and but fifty yards south of the road, there is a very small bed of altered crystalline limestone, consisting chiefly of calcareous spar, including scattered crystals of *plumbago epidate* and other minerals. It seems to have been a small lenticular bed into which a dyke or thick vein of sienite has been protruded, the excessive heat of which, when in a melted state has probably modified the rock to the crystalline structure described.

At another locality further north, near Shuter's mill, on French creek at the margin of the red sandstone occurs another bed, of highly crystalline sparry limestone, similarly affected by a dyke of igneous rock and containing beautiful crystals of *plumbago* and other minerals. The intrusive rock seems to be a species of serpentine. These beds of limestone have been wrought to a very moderate extent, the cost of qarrying them being considerable and the lime though fit for agriculture, being rather too dark for the purposes of the plasterer. The structure and mineral character of this calcareous rock, seem identical with those which characterise the belts of altered secondary limestone, which range so extensively along the southern margin of Kittatinny valley across New Jersey.

Small trap dykes are common in the townships of Vincent and East and West Nantmeal. The two high hills near Warwick Furnace consist of trap—the largest mass of this rock in the township. Nearly two miles below the Yellow Springs, on the road which leads direct to the valley, and on the middle branch of the Pickering, there is another, but much smaller, bed of limestone, which has been altered in a similar manner to those above described. The rock that surrounds it is a kind of sienite, and the limestone is crystallized and contains *plumbago*. A fourth bed of the same species of limestone occurs on a small branch of the Brandywine, one mile and a quarter north-east from the Eagle tavern. Like the others, it has been altered by igneous action, and is coarsely crystallized, and contains *plumbago*. Above the Friends' Meeting House, a bed of a singular, hard, hornblendic rock, crosses the road; appearing, also, on the road leading from the Yellow Springs to the Red Lion, two miles above the latter place. Pipe clay occurs in Uwchland township, in considerable abundance. Graphite is said to occur in West Nantmeal, disseminated through blue quartz, but none was met with.

Iron ore is found at several localities. Near Isabella Furnace, a vein of *titaniferous iron ore* occurs on the farm of Mr. Green, yielding 59.44 per cent. of metallic iron. The titanic acid which it contains, forming a titanate of the protoxide, renders the ore difficult to flux, and consequently the manufacture of iron from it has been abandoned. Large quantities of this ore were taken to the lower part of New Jersey some years since, for the purpose of mixing with the *bog iron ore* of that district, and was worked with some success. Its chemical composition is given in Chapter VI.

A little below Waynesburg, near Felt's mill, there is a dyke of trap, extending in a nearly east and west direction. On the road from the Mariner's Compass to the United States Arms, one mile south of the Lancaster turnpike, there is a bed of limestone, which may belong to F. II., as it is situated on the margin of a hill of sandstone consisting of F. I. It is not altered: the color of the rock, which is fine grained, is a light blue. The area which it occupies is limited. In this township, fifteen thousand perches of limestone are said to be quarried annually.

In Brandywine, and the greater part of West Caln township, hornblendic rocks are common; but in Sadsbury, in Lancaster county, gneiss, usually the granitic kind, and mica slate, are the prevailing strata.

If we trace the line of junction between the primary rocks and the limestone F. II,, we shall find it commencing near the western extremity of the Welsh mountain, on the southern side of the hill, and passing near the Pequea Meeting House, in an undulating line. It crosses the county line between Chester and Lancaster a little above St. John's Church, and then runs south and south-west to join the sandstone of the Mine ridge. Following the foot of the Mine ridge on the north side, it leaves the sandstone after a while, and passes about a mile below Strasburg and on the Pequea creek, where some traces of F. II. are visible along the creek, some distance below the main beds of the limestone, not having been denuded. From thence it continues to Willow Street, and is prolonged to the Conestoga, near Wybin's mill. It follows the creek downwards to Hershey's mill, above Safe Harbour, where it crosses and passes round the east and north sides of Turkey hill, reaching the Susquehanna at Wistler's run. A small isolated patch of secondary limestone F. II. has escaped denudation, on the Little Beaver creek, at Jacob Neff's fulling mill, about two miles from Strasburg.

In Bart township, north of the valley limestone, and between the North Valley and Mine Ridge ranges, which consist of sandstone, the gneiss and mica slate occur, and continue, with some slight variations, to the Susquehanna. Turkey Hill is composed of talc and mica slates, which become the prevailing rocks as we approach the river.

Iron ore occurs on Big Beaver creek, in Bart township, near the mill of A. Bare, at the foot of Mine Ridge. It is an argilaceous ore, situated in detritus that has probably been brought down from the neighboring sandstone hill. Much of this sand and loose matter is intermixed with the ore, which has been worked for many years. Iron ore also occurs and is dug near Shenk's tavern, on the Susquehanna, not far from Stoner's ferry. It is an argilaceous ore, and lies near the side of the hill. It is brought to the river to be transported to other places.

Limestone of the Great Valley.

This belt of limestone, which forms the Great Valley, and extends through the western half of Montgomery county through Chester county and Sadsbury and Bart townships, in Lancaster county, commences about a mile and a half south-west of Willow Grove. Tracing it along its southren margin, we find it entering the north corner of Cheltenham township, crossing the Bethlehem turnpike near the Running Pump tavern, a mile below Flourtown, and thence passing to Spring Mill on the Schuylkill, where it crosses the river and follows Gulph creek, through Upper Merion township, into Chester county. This line, after passing the county line, a little less than a mile south of the Baptist Meeting House, follows the foot of the South Valley hill about the same distance north of Glassley and north of the Paoli, to within a couple of furlongs of the Warren tavern, and from thence half a mile south of the Steamboat tavern, and somewhat more to the north of the Indian King. Near Downingstown, it has decreased much in width, being little more than three-fourths of a mile broad. The line passes about two furlongs south of the town. From Downingstown, the foot of the hill indicates the margin of the limestone, which passes rather less than a quarter of a mile below Coatsville on to Freeman's mill, on Buck run; thence to Cloud's mill, near Phillip's tavern, on the Gap and Wilmington turnpike; and to the Octarara creek, near the junction of Cloud's run. In Lancaster county, it follows Cooper's run as far as the dam near the Valley mills, but afterwards continues along the valley a furlong south of the stream. We then trace the same southern margin across the west branch of the Octarara, about a fourth of a mile below Buckman's tavern, and thence to Kunkle's and Eckman's run, at which place the limestone terminates. On Eckman's farm, the line doubles back towards the east, and pursues nearly a straight course, by the Reform Meeting House, to Buckman's tavern; thence running straight to the Octarara, a fourth of a mile above Noble's factory. Its greatest width in Lancaster county is not much more than half a mile. Returning into Chester county, it continues direct to Parkesburg. At Coatsville, it passes one and a half furlong north of the villiage. Two miles east of Coatsville, the belt widens, and passes a fourth of a mile south of East Caln Church. Still expanding, the northern margin passes one-third of a mile north of Downingstown to West Whiteland township line, where it is within a furlong and a half of the Valley turnpike; and thence continues north-east for about three and a half miles. The width of the limestone, taken along the east township line of West Whiteland, is a little more than two miles; and the northern margin is a nearly straight line from thence to the Valley creek, which it crosses half a mile from its junction with the Schuylkill. As the belt passes into Upper Merion, it its overlaid on the north by the red sandstone—a portion of which jutting out in the form of a loop as far as the King of Prussia tavern, conceals that part of the formation which lies to the north of Reesville. From thence, the northern line continues direct to within half a mile of Norristown, and turning down towards Swedes' Church, crosses the Schuylkill one mile below the bridge. Doubling south a short distance from the river, it forms, in Plymouth township, another loop, and then crosses the Ridge turnpike at the fourteenth mile stone from Philadelphia, and the Germantown turnpike a little more than a quarter of a mile below the fifteenth mile stone. It then passes into Whitemarsh township, crossing the Wissahiccon at Mather's mill, a short distance below Sandy Run, following the run until it reaches the eastern extremity of the belt in Abington township, near Willow Grove.

That portion of the formation which enters Abington township, is more slaty and fractured than that further to the west, and it also contains, apparently, a larger amount of salica. Those portions of the rock which are exposed, or are nearest to the surface, have in many places undergone partial decomposition, and have the appearance of a white calcareous sand. This sandy aspect of the limestone may be observed in all the quarries in the neighborhood of Sandy Run, and also at many other localities. Mostly, however, unless the rock has undergone partial decomposition, the limestone is crystalline and granular; varying in color from blue to white, as a greater or less amount of carbonaceous matter may enter into its composition. Each of these colors is not confined to a particular stratum, but varies repeatedly in the same bed, and, indeed, the area occupied by one particular color is usually very small. The dip throughout the whole formation is remarkably uniform. Near Sandy Run it is towards the south and S. S. E. Quarries and pits have been opened on almost every farm along Sandy Run. One of the largest in this vicinity is on the farm of Mr. Fitzwater, near Fitzwatertown. The limestone is chiefly blue, the dip S. S. E. at an angle of about sixty degrees. The practice of the landholders is to let out the right of working the quarry for a certain period, and the tenant during that time may excavate as much stone as he may require. Many quarries, also, are opened and worked by the proprietor for his individual supply. No record is, therefore, kept, to enable us to ascertain the number of perches annually quarried.

Near the Meeting House, about a mile above Flowertown, a trap dye crosses the Bethlehem turnpike in a north east and south-west direction. It is about two and a half miles long, commencing near the north-west line of Springfield township, and ranging past Bickell's mill on the Wissahiccon to the school house lying half a mile further west. The protrusion of the dyke has not disturbed the adjoining strata to any serious extent. A marble quarry has been opened south of the dyke, near Beck's mill. The rock is granular, and its predominant color is bluish. Crystals of *fluate of lime* occur in this quarry. About half a furlong north of the dyke, there is another quarry on Bickell's farm, in which the beds are somewhat contorted.

At the Episcopal Church, near Seller's tavern, the limestone includes a band of stratified felspathic rock similar to that which is interposed between it and the gneiss bounding it on the south. This bed is small, but forms a steep hill, which crosses the road diagonally. It has the same range and dip as the limestone including it. It separates into small fragments, often rhomboidal in shape, and is used for repairing the turnpike, being quarried for this purpose.

Another band of somewhat similar felspathic rock occurs on Sandy run, near the margin of the red sandstone. It differs from the last in being less readily decomposed and in containing small crystals of hornblend. It is a very local occurrence, only a few layers of it peeping from beneath the overlapping sandstones. The spot is at a smith shop on Sandy run, a mile east of the turnpike.

On the turnpike opposite Sellerstown, a limestone quarry of some size is wrought, the rock making an excellent lime. An extensive quarry of the same, nearly white, variety of the limestone exists on Mather's farm. There, the beds are crossed by very regular joints, giving the appearance of a stratification, in another direction; the true dip is towards the south.

Traces of *iron ore* occur at several localities in Whitemarsh township, but we meet with no deposites of magnitude until we approach Barren Hill and Spring mill. Near the Germantown turnpike, about a fourth of a mile above the Plymouth Meeting House, are the limestone quarries of Wright and Johnson. Much of the stone in this neighbourhood is beautifully white, though some layers occur having a more or less blueish tint. The weathered surface of many beds is rough and sandy, showing some siliceous matter in the rock. At Marble Hall an extensive quarry of white marble is worked by Mr. Hillman. Some of the beds at this place are remarkably white and uniformily crystalline, while others of simlar texture are bluish or pinkish and some contain small flames of *green talc.* That portion of the quarry from which the best marble is procured is merely a bed, a few yards in thickness dipping S. S. E. at an angle of eighty degrees. About fifty yards further on, another quarry of very similar marble but of a bluer color is wrought. The beds here are not quite so thick. Near the turnpike, on the farm of Mr. Hilder, small beds of *brown iron ore* have been discovered, from which a moderate quantity has been sent to the Schuylkill to be smelted. The ore is rather too siliceous to yield a good iron, with facility. The deposite extends into the adjoining farm, where a small pit has also been dug. Earthy *plumbago* and *black oxide of manganese* occur in both places mixed with much soil and clay. About a fourth of a mile further down the road, two other marble quarries occur in which the beds are nearly perpendiculay dipping rather towards the S. S. E. These quarries are not so actively wrought as formerly, when blue marble was in more request. Within a few fields of the quarries, a small body of *iron ore* has been found, resembling in most respects that above referred to. This ore is sandy and not well adapted to make a superior iron. *Iron ore* also occurs on both sides of the Ridge road, near the twelfth mile stone and is dug to a moderate amount. This deposite is rather less sandy than that on the Germantown turnpike. A range of calcareous talcose slates, lies in contact with the felspathic stratum of Barren Hill, extending westward, though not with much regularity to the Schuylkill. They pass into a slaty talcose limestone. In many parts of the general limestone belt, the change from compact to slaty limestone arises from the introduction of talcose matter. The compact, thickly bedded white limestone at Spring mill, seems to be a continuation of the talcose beds in contact with the felspathic rock of Barren Hill. Talc slate occupies a band in the limestone, about two miles north of the Barren Hill church.

Iron ore occurs in the neighborhood of Spring Mill and Conshehoken, on several farms. That belonging to Mr. Kuhnzey, near the township line has been opened, but to a moderate extent. Nearly all the ore in this neighbourhood is more or less siliceous. For its chemical composition see chapter VI. A quarry of dark blue marble is wrought near the thirteenth mile stone on the Ridge turnpike. In this and another adjoining quarry, the marble is chiefly of the blue variety. The beds dip at a steep angle towards the south, that furnishing the best marble, being sufficiently thick to render the labour of quarrying it less than at some of the quarries already mentioned. A fine natural section along the east bank of the Schuylkill, exposes nearly the whole of this primary limestone belt across its entire breadth. The predominant dip is at an angle of sixty or sixty-five degrees towards the south. From its northern margin for about one mile south, the limestone frequently alternates with thin seams of talc slate and contains thin veins of apparently injected quartz. South of this occur alternating beds of light blue limestone, the change occurring every few yards, until within a mile of Conshehoken, where talc slates begin and extend south to the villiage. At Conshehoken, a trap dyke crosses the river in a E. N. E. and W. S. W. direction, commencing at the Ridge road at the twelfth milestone and extending westward four miles. The talc slate which crosses the Schuylkill near Horry dam, extends along the Gulf run and gradually thins out. Beyond this to the west, the main body of the limestone lies in contact with the talc slates of the southern primary belt which contain no calcareous matter and which form a moderately elevated ridge, extending across the whole of Chester county, separating the calcareous belt from the mica slate still further south. In that portion of the Limestone Valley which occupies the southren part of Upper Merion township, especially in the immediate vicinity of the Schuylkill, there are numerous and extensive quarries, furnishing a large supply of the rock, a portion of which is transported to Philadelphia, and other places, by the several rail roads and the Schuylkill navigation, a large amount being converted into lime on the spot, designed for the same markets.

A large quarry of the limestone is wrought on the west side of the Schuylkill, two or three miles below Valley Forge, where the rock is tolerably thick bedded and of a light color. The quarried stone is conveyed to the river by a rail road, and thence taken by boats to the various lime kilns. Extensive quarries have also been opened near the Valley Church, where the limestone is very similar to that of the last locality, dipping steeply south, being of a light tint, and furnishing an excellent lime. On the road from Glassley to Valley Forge, near the county line, there is a small bed of slaty, talcose, calcareous rock extending east and west about three furlongs in length towards Valley creek. It constitutes a small hill, over the east end of which the road passes. Near Valley Forge, occurs a stratum of felspathic rock, like that seen at Barren Hill. It is exposed in the creek and occasionally appears emerging from below the sandstone of F. I. at the foot of the North Valley Hill, a little east of the Valley Church. The limestone near the White Horse tavern in East Whiteland township, is occasionally talcose and slaty. Nearer the Steamboat tavern, the more usual granular structure prevails. Throughout all this range, however, the rock makes excellent lime. A little south of the Valley turnpike about three and a half miles east of Downingtown, is the extensive quarry of superior white marble, which has for many years supplied Philadelphia with the beautiful article, employed in so many of its public and private edifices. It is on the farm of Mr. John R. Thomas. The beds on this quarry are slightly contorted. The portion worked for the marble, separates into two bands. The rock occurs in massive beds, chiefly white, with sometimes a bluish tinge, and is quarried with great facility. It has been much used in the construction of the Girard College, and other public buildings, which adorn Philadelphia and the neighbouring towns. It is valued at about three dollars per cubic foot. This marble is converted into a good lime, but its crystalline or granular structure causes it to crumble in the kiln, making it a little difficult to manage. This variety is much esteemed by masons, being sold in Philadelphia under the name of *Fish-egg lime*, a name suggested by its granular structure. In the year 1838, it is estimated that twenty-five thousand nine hundred and ten perches of limestone were quarried in this township. On the farm of Mr. H. B. Jacobs, there is a quarry of dark blue marble, of excellent quality but the demand for this variety has, of late years, declined. At Downingtown the limestone is chiefly of a light color and compact. Two quarries, one, of a compact, the other of a more granular limestone, have been opened on the farm of Mr. Hunt, who, from some experiments which he has made, gives the preference to the lime made from the granular variety. The analysis given in Chapter VI. will show the relative composition of these two species as they exist in this neighbourhood.

The limestone belt is crossed obliquely by a small *trap dyke*, ranging north-east and south-west, which intersects the rail road near Hunt's farm. The width of the formation, near the East Caln Church, is reduced to about three-fourths of a mile. It is somewhat variable, being dependant, probably, upon the angle of the dip; which, however, is pretty constant. At Coatsville, it does not exceed three furlongs. At Bell's quarry, Midway, the rock is light colored. About a mile east of Trueman's mill, we find a small bed of *white clay*, derived from the decomposition of a felspathic stratum lying between the limestone and the talc slates. In the vicinity of Buck's run and Parkesburg, the limestone becomes darker and more slaty. In passing Cloud's mills into Lancaster county, it gradually declines in thickness, being at Cooper's fulling mill, in Strasburg township, not more than two furlongs wide. At its termination in Bart township, it becomes more than usually sandy, especially near its margin. The main belt seems to terminate on Eckman's run; but another small lenticular belt shows itself a mile and a half further to the west, on the premises of Mr. Bare, where the rock is quarried.

At Gallagherville, a quarry has been opened upon a vein of crystalline white marble, which promises to afford blocks of building material with facility. The bed is narrow, inclining to the south, at a high angle, and will probably increase in value the deeper it is excavated. Iron pyrites occur in this locality.

Throughout the whole valley, the dip of the formation is very nearly constant, varying usually between sixty and seventy degrees, directed towards the south and S. S. E. Mr. W. P. Townsend, of West Chester, estimates that, in 1838, not less than six hundred and eighty-five thousand two hundred and forty-one perches of limestone were quarried within the limits of Chester county, producing, at the average price of sixty cents per perch, 411,144 dollars; but it is probable that this estimate is somewhat too low.

Of the Primary Rocks in the Southern part of York County.

We shall now proceed to describe the primary strata as they occur along the west bank of the Susquehanna river, where they are well exposed by the excavations made along the newly constructed canal The rocks near the southern State line are chiefly talcose and micaceous slates, occasionally containing arenaceous bands, approaching in structure to a fine grained sandstone. Near Cooper's Point, occur minute but beautiful crystals of *octohedral iron*. At the second lock above the State line, we find a siliceous stratum, fifty feet thick, regularly intersected by cross joints, which is extensively used for the construction of the locks and walls of the canal. Slate Point is a high projecting hill, so named from the roofing slate found in it. This slate splits with tolerable regularity, and affords a durable roofing material, but it is difficult to quarry. The chief portion of the slate now procured on the west side of the river, is taken from the same ridge, two miles distant. The completion of the canal will lend importance to this belt of rock. Talc slate is almost the only rock visible from Muddy creek to M'Call's Ferry, a distance of four miles. The dip here is between fifty and sixty degrees toward the S. S. E. In an extensive excavation along the canal, at one place ninety-two feet in depth, we find the purple *sulphrute of copper*, with a little green and blue *carbonate of copper*, enclosed in irregular veins of *white quartz*. On the south bank of Otter creek, one hundred yards from the river, we come upon York Furnace, near which occurs a thin band of limestone, enclosed in talc slate. It is but two feet thick, the more compact part appearing to be adapted for agricultural purposes. It does not make a good flux for iron ore, being too magnesian.

At Shank's Ferry, the formation embraces a fine grained gneiss rock. Opposite to this, on the eastern side of the river, a bed of limestone occurs, employed as the flux in York Furnace. The ore smelted at this furnace is from the large mine at Chesnut Hill, near Columbia. Above Turkey Hill, we meet with a nearly perpendicular limestone, in the low grounds between the ridge and the mouth of Cabin Branch run. It is much mixed with slate. This calcareous rock terminates in a wedge shaped point, a few miles west of the river. It is not a part of the primary formation, but a prolongation of the lower, secondary limestone of F. II. of Lancaster county. It is quarried at two or the places near Cabin Branch run. About one and a half miles above Burg's mill, we find a bed of the limestone, having the aspect of a very coarse conglomerate, composed of masses of grey limestone, imbedded in a dark slaty cement. This is about one hundred feet thick. Above the mouth of Cabin Branch run, we pass over a broad belt of dark slate, nearly a mile in width. Near its northern margin was seen a large lump of *iron ore* sticking in the bank, though there seems little probability of finding a valuable deposite of the mineral at this place. Dipping under this slate at an angle of seventy-five degrees to the south-east, is a belt of impure slaty limestone, three hundred feet in thickness. This belongs apparently to the alternating rocks at the junction of F. s. I. and II. Its position is about one mile below Wrightsville. A calcareous and arenaceous rock, referable to F. I. extends along the canal about half a mile, terminating near the first lock below Wrightsville. The limestone at the mouth of Cabin Branch run, the prolongation of that of Lancaster county, extends about three miles west from the river, losing itself a little west of Margaretta Furnace, where it is much interstratified with slate. East of the forge, and lying south of the limestone, occurs a compact siliceous and talcose slate, of much beauty, employed for the locks, &c. on the canal. It is more than two hundred feet thick. Margaretta Furnace, two miles from the river, on the Cabin Branch run, is supplied with *ore* from a deposite in its immediate vicinity, which lies near the northern margin of the slaty limestone, near its junction with the slaty sandstone of F. I. The *analysis*, showing the prevailing composition of this ore, will be found in chapter VI.

A somewhat promising locality of roofing slate exists in the Slate Ridge north of the above limestone. It occurs about two miles south of the York and Wrightsville rail road. In a rather wild and sequestered neighbourhood, among the Barren Hills, thirteen miles south-east from York, we come upon Susan Ann Furnace, not recently in operation, but undergoing repairs. The *iron ore* procured near it was found to make an inferior metal, and was abandoned for a purer variety, obtained about seven miles to the west, at a point seven and a half miles south of York, where the mineral occurs, between seams of disintegrated slate, in nests and loose deposites. It is rather siliceous, but is said to yield a tolerably good iron. Near the Maryland line, at Essex Hall, on the farm of Mr. Clark, a small deposite of iron ore was worked some years ago. In the fields between this and the State line, are found loose crystals of *red oxide of titanium.* At the State line, five miles west of the river, we find a small ridge of serpentine. It is about a mile long, and lies principally in Maryland. In this belt the mineralogist may obtain fine specimens of *green serpentine, actinolite, chlorite,* and *asbestos titaniferous iron ore,* and *magnetic iron ore.* A band of chlorite slate, near the northern base of the ridge, contains, in abundance, beautiful *octohedral crystals of iron.* Like the serpentine belts of Chester and Lancaster counties, that above described occurs in lenticular form, in the talcose and chloritic slates. Two miles eastward of this point are the slate quarries already noticed as belonging to the ridge which crosses the river below Peach Bottom. The quantity of roofing slate procured here is considerable. Specimens of *Wavellite* are met with in the quarries.

About a quarter of a mile west of the York and Baltimore rail road, and ten miles south of York, a thin band of impure limestone is imbedded in the slate, and quarried on the farm of Mr. Daniel Diehl. Westward from Diehl's towards Jefferson, it is excavated at several localities, and converted into lime for the fields. At Christian Knull's, east of Jefferson, we meet with indications of iron ore.

The junction of the slate and limestone rocks, F. I. and F. II. is seen on the south of the Pigeon Hills, about four and a half miles north-east from Hanover. One mile south of Hanover, we meet the line of contact between the limestone and slate, ranging north-east and south-west, and passing half a mile south of Littlestown, bringing the margin of the slate to the Maryland line, near Arnold's mill. The limestone belt of the York valley, lying on the north-west of the slate, terminates near this in a wedge shaped point, by the folding round of the overlapping, middle secondary red sandstone, which, after concealing the limestone, encroaches upon the slate.

SECTION II.

Of Formation I. and II., lying North of the Southern Primary Region in Chester, Lancaster, York, and Adams Counties.

FORMATION I.—*Sandstone and Slate.*

The extensive slate and sandstone formation which constitutes the lowest member of our Older Secondary or Appalachian rocks, has evidently, at one time, overlapped the southern primary belt in a much wider area than that to which it is at present limited. Some further research is requisite in order to determine with precision its true line of junction with the talcose slates west of the Susquehanna. The slaty rocks of the formation approach often so nearly to the character of the primary schists, as to render it somewhat difficult to delineate their respective limits. The white sandstone constituting the upper division of the formation is everywhere easily recognised. The principal tracts of the formation which have been spared in the general denudation, which has removed so much of the surface rocks in this southern section of the State, are, if we except the more extensive belts of the South mountains, a few insulated, narrow ridges in Chester, Lancaster and York. These form the North Valley Hill, Mine Ridge, Welsh Mountain, Chicques Ridge on the Susquehanna, and the Pigeon Hills in York.

The first of these belts caps the hill bounding the Great Limestone Valley of Chester county on the north, the whole distance from the Valley creek near the Schuylkill, to Bart township, in Lancaster county, forming a long and narrow zone of sandstone resting unconformably near the edge of the limestone and the gneiss. It is nearly of the same width throughout, dipping gently southward. Its prevailing character is that of a more or less granular whitish sandstone.

The next long belt of this formation commences west of the village of Sadsbury, and under the name of the Mine Ridge, passes into Lancaster county terminating on Big Beaver creek. At a gorge in this ridge on the Newport turnpike, the rock is much disintegrated, yielding fine white sand. On the line of the rail road in Sadsbury township *red oxide of titanium* occurs near the margin of the formation in some abundance. It is a mineral for which there is a small demand, being employed in the manufacture of porcelain teeth. Its value is about five dollars per pound.

Between the township of Honeybrook and West Caln, commencing near the Lancaster turnpike, above Wemer's mill, and extending westward nearly as far as the county line, there is a steep hill consisting of this formation. On the road from Downingstown to the Red Lion, in the lower part Uwchland township, the same rock occurs, in a small isolated hill running north-east and south-west for about a mile. We have already mentioned the occurrence of a similar detached hill of this sandstone near Londongrove. Another called the Buckingham mountain near Centreville, will be noticed in the chapter on the middle secondary red sandstone formation.

In my report of last year, the limits of the other belts of this formation, lying between the Delaware and the Susquehanna, including those of the South mountain, were traced with sufficient exactness. The limited scope of an annual report compels me to postpone the description of the local geology, not only of this formation but of the other secondary rocks of all that part of our first or southern district lying east of the Susquehanna.

Our explorations during the past year, were extended over nearly the whole of Bucks and Montgomery counties, but the necessity of collecting some further details, and the want of space, induce me to leave to another time, the description of the Great Red Sandstone formation, with its minerals, which constitute so large a portion of those counties, and which, will be best discussed, when time allows me to introduce the details of the entire belt in its range through Bucks, Montgomery, Chester, Berks, Lancaster, Lebanon, Dauphin, York and Adams, in all of which counties, it has been now explored.

In detailing a portion of the observations made during the last season in York and Adams counties, I propose therefore, to omit the Red Sandstone belt, and confine myself to the Lower secondary rocks lying south-east and north-west of this range.

Of the Slate and Sandstone of Formation I. of the Pigeon Hills.

About eight miles south-westward from York, commences the range called the Pigeon Hills, rising through the limestone of the York Valley. These hills have an eliptical form, are between seven and eight miles long and three broad, terminating south-westward near the turnpike, at a point four miles north of Hanover. The strata of these hills, comprising different portions of F. I. consist usually of a dark slate and a light colored sandstone, of different degrees of fineness and compactness. The whole belt, though carefully explored, developes little of interest in an economical point of view. About four miles N. N. E. from Hanover, occur *green chlorite*, and a beautiful variety of *foliated oxide of iron.* The slate in the neighborhood shows small traces of *copper ore.* A belief exists throughout this neighborhood, that the slates of these hills are of the coal formation, and that coal perhaps exists in them; whereas they belong to the very lowest secondary formation of our State, while the workable coal is exclusively confined to a wholly different group of rocks, lying much higher in the order of stratification, and occupying an entirely different geographical range.

Of the Limestone F. II. of York Valley.

Resuming our observations along the Susquehanna, we find the southern margin of the limestone designated as F. II. near the south side of Creitz creek, below Wrightsville, where it is quarried for building stone, for the locks, &c. of the canal. The dip is towards the S. S. E. at an angle of seventy degrees. Another large quarry occurs on the north side of the same creek; while a third, in which we find some beds of variegated limestone, is wrought a little north of the bridge. The northernmost exposure of the rock near the river, is in a quarry a quarter of a mile above the bridge. The limestone here is nearly white, and has the aspect and structure of a marble, but is much traversed by cross joints, and is hence difficult to procure in large blocks. From this vicinity towards York, we notice several varieties of the limestone, some belts of which are highly magnesian, and therefore well adapted for the manufacture of *hydraulic cement* It is a matter of just surprise that we have hitherto had no manufacture of this valuable article any where in the southern limestone belts of this state, where the material is so abundant, and where outlets to market, procured at so vast an expense to the Commonwealth, are numerous and convenient. Many chemical analysis already made, and others now in progress in the laboratory of the Survey, establish the fact, that *nearly all* the limestone belts in the south-eastern district of the State, including also those of the Kittatinny Valley, contain bands of magnesian limestone capable of furnishing a hydraulic cement identical in properties with that so extensively manufactured in New York, and on the Potomac, near Sheperdstown.

The town of York is scarcely a mile from the southern border of the limestone; and the excavation for the rail road, a little south of the town, shows a slaty character, denoting its passage into the slate on the south. North of the Codorus, it is extensively quarried and converted into lime. Stet generally light grey or whitish One mile north-west of the town, are extensive quarries, in one of which occurs a beautiful flesh colored marble, but not in beds thick enough to be profitably wrought. On a hill half a mile west of the town, a variegated, silicious and calcareous rock is quarried for a building stone.

That part of the limestone belt south of the Pigeon Hills ranges between their eastern end and the slate ridge to the south, and passing by Spring Forge, advances towards Hanover. South-west of the forge, the belt becomes quite narrow and interrupted by belts of slate; but it may be traced continuously between the slate ridge, or "Barrren Hills," on the south, and Pigeon Hills on the north.

A belt of *iron ore* is traceable along the southern edge of this limestone, near the slate, for several miles. It passes a little south of Hanover and thence towards Littlestown. This ore was mined many years ago, but has long lain neglected, owing to the inferior quality of the iron which it produced, in consequence chiefly, of its containing a considerable portion of the *oxide of manganese.* It occurs in considerable quantity in a small hill two miles south-west of Hanover; from which point to Littlestown, detached lumps of it are visible in the soil for nearly the whole distance.

The red sandstone passing from the west end of the Pigeon Hills, encroaches upon the limestone as it advances south, until near Arnold's mill, at the State line, it overlaps the whole of the formation.

Along the southern base of the Pigeon Hills, in the slates north of the margin of the narrow zone of limestone already traced, we find another belt of *iron ore*, of less length than that on the south side of the limestone. At Moul's five miles north-east from Hanover, the ore was dug about forty years ago. Much of it is scattered about the fields. Huge rocky concretions of ore protrude themselves at the base of a spur of the Pigeon Hills, about three-fourths of a mile to the north-east. The thickness of this deposite of ore is very great, not less perhaps than one hundred feet; but the mineral is extremely siliceous, and unless a new method of working it were devised, would not justify attempts at smelting it. It is possible, however, that by the use of anthracite coal, aided by the hot blast, not only this, but many other siliceous and impure ores, if rich enough in iron, will be found ultimately capable of yielding a tolerably good metal, while with the inadequate heat from charcoal they prove quite refractory.

The northern border of this division of the limestone, after ranging along the southern side of the Pigeon Hills, folds round their south-western termination, and meets the overlying red sandstone on their northern declivity. Extensive limestone quarries, producing a valuable lime, occur on the farm of Mr. Adam Myers, near the end of the hills. A limestone quarry exists on a farm belonging to Mr. James M'Sherry, near Conewago Chapel. Some of the beds yield a fine, compact, light colored variety, promising to be susceptible of a good polish as a marble. It affords a good lime.

The northern division of the limestone is overlapped, as we have said, along the northern base of the Pigeon Hills. It appears, however, a little east of King's tavern, ten miles from York. The course of the southern margin of the overlapping red sandstone from this point is nearly north-east, passing within two and a half miles north-west of York. Between York and the spot at which the limestone disappears at the base of the hills, it is much traversed by small ranges of slate.

The anticlinal ridge, consisting of the white sandstone and overlapping slate of F. II. prolonged from Chicques ridge at the river, ranges along the northern edge from Wrightsville nearly to York, within a mile and a half of which it terminates. The limestone folds round its western end, and extends north-eastward between this ridge and another of siliceous slate, running westward from the Codorus. These uniting, the limestone ceames, in a point, north of the belt of siliceous slate just mentioned, which belongs, apparently, to the upper portion of F. I. We find another small wedge-shaped tract of the limestone crossing the river below Bainbridge, and extending westward about a mile, when it is overlapped by the red sandstone, about a mile north of New Holland. About half a mile west of the river, near its southern margin, we find lumps of *iron ore* in the soil.

Of the Sandstone and Slate of Chicques Ridge, west of the Susquehanna.

The general structure of this ridge is that of a very much compressed or folded anticlinal axis, on the northern side of which the strata lie in an *inverted* attitude, that is to say, the rocks, originally uppermost, are seen dipping apparently beneath others, generally inferior to them in the order of stratification. The consequence is that the limestone of F. II. lying north of the ridge, dips southward, to underlie the rocks of the ridge which consist of F. I. Above the bridge at Wrightsville, the most southern belt of F. I. is a slaty sandstone evidently one of the upper strata. It dips seventy degrees south. Approaching the main axis of the ridge, we meet high perpendicular cliffs consisting of the lower sandstone division of the formation. The color of the rock is whitish, sometimes of a bluish tinge. About a mile below the mouth of Codorus creek to the north of the folded axis, the sandstone is underlaid by a tolerably thick belt of striped slates, this again, by a succession of thick strata of sandstone and slate, the latter predominating, until we reach the limestone at New Holland. These slates constitute the upper division of F. I. Their general posture is nearly perpendicular, though sometimes they dip slightly north from the axis and sometimes they are *inverted*, or dip towards it. Half a mile above the furnace on Codorus creek, the compact white sandstone dips north sixty degrees. From this to Brillinger's, we see no more of the sandstone, the rock being the upper siliceous slate similar to that at the mouth of the Codorus. The belt of white sandstone terminates westward at a point at about two miles north-east of York, where the Codorus flows round it. The belt of siliceous slate, lying further north, passes westward from the mouth of the Codorus and New Holland, ranging south of Liverpool, until it is covered by the red sandstone at Shultz's, four miles north of York.

Of the Limestone F. II. near the southern base of the South Mountain.

The most north-easterly point at which we observe the limestone, immediately south of the South Mountain, is about a mile and a half north of Petersburg, where a beautiful white and compact variety is opened in a quarry belonging to Mr. James M'Cosh. About half a mile south of this, on the opposite side of a trap ridge, which intersects the formation, occur quarries belonging to Mr. Picking. The rock is here of a light grey color and remarkably soft, being further removed from the modifying influence of the once heated trap rock. Another extensive quarry occurs in the same neighborhood, two miles north west from Petersburg. Much search has been unavailingly made for limestone among the hills near the base of the mountain, ten or twelve miles westward of Petersburg, from whence the lime at present procured is all brought.

The next point at which we notice the limestone, is about two miles north of Fairfield, at Mr. James Blythe's. The rock here is of several shades of color, purplish, greenish and some of it nearly white and crystalline. On the west side of Middle creek, below Myer's mill, it again shows itself but is not quarried. The paucity of the exposures of limestone through this belt of country is due, unquestionably, to the extensive manner in which the lower secondary rocks are overspread by the Middle Secondary red shales and sandstones, overlapping every thing beneath them as far as the base of the hill.

The Rocks of the South Mountain.

The irregular chain of hills termed the South Mountain bounding the Kittatinny or Cumberland valley on the south-east, and crossing the Susquehanna, in their progress to the south-west, consist of a broad belt of nearly parallel ridges, the general direction of whose axes is not exactly coincident with the prevailing course of the mountain, the latter being nearly from north-east to south-west, while the direction of each individual ridge or axis is more nearly E. N. E. and W.S.W. In consequence of this, the several belts of rock, range somewhat obliquely across the general course of the mountain. Thus, the coarse talcose sandstone of "Green Ridge," from ranging rather on the north-western side of the mountain belt on the State line, constitutes the middle ridge in the neighbourhood of Cold Spring, while a few miles further east it appears on the southern side of the chain.

A section across the rocks on the south of Green Ridge in Adams county, embracing the exposures on the Gettysburg rail road, will serve to show the general structure and composition of these hills.

Passing a *trap dyke* at Biesecker's, west of Gettysburg, the first excavation where the rock of the mountain is exposed shows a compact, grey, siliceous, stratum much traversed by cross joints. Below this occur a few feet of talc slate, under laid by chlorite slate. East of Middle creek is a hard grey siliceous rock and near it a chlorite rock containing specks of *epidote*. A little *iron ore* was found loose in the soil here. We next pass alternations of the grey siliceous rock and greenish slate and afterwards a deep excavation in a hard grey siliceous stratum, containing specks of *white felspar*. This includes a bed of beautiful veined grey rock. Passing the viaduct, one hundred feet of grey slate is seen graduating into sandstone. About half a mile from the end of Jack's mountain, a hill nearly seven hundred feet high, the bluish slate is interstratified with sandstone. Further to the south-west, the sandstone becomes less talcose and more siliceous. Without any material variation, this extends to the contemplated tunnel near the western end of Jack's mountain, embracing probably a thickness of one thousand feet of this limestone. Near another projected tunnel in a ridge uniting with the north-west side of the mountain there is a hard epidotic and quartzose rock of considerble thickness and near it a greenish slate. On the southern side of the next ridge, is a thick belt of a similar green slate, including bands of grey slate spotted with *epidote*. About a mile and a half south-east of the intended summit of the road, is a cutting in dark grey slate, then occur greenish slate and a purplish grey siliceous rock, spotted with some crystallized epidote. Further on we find an epidote rock containing asbestos fron which to the end of the cutting occurs a dark grey siliceous rock. Near the summit a flat swamp occupies a considerable area on the top of the mountain. Near Red run, a branch of Antietam creek, a compact siliceous sandstone shows itself, similar to that along the south side of Jack's mountain. This terminates the excavation on the rail road.

On the road from Fairfield to the Emmetsburg and Waynesburg turnpike near Miney run, diggings to some extent were undertaken, several years since in search of *copper ore*. Nothing is visible in the materials dug out, calculated to inspire a hope of finding a productive copper vein in this locality. In a small ridge north of Jack's mountain, several openings from copper ore were commenced by Mr. Thomson, and a small quantity of ore obtained and a furnace built for smelting it. These works are now abandoned. The metal occurs in the form of green and blue carbonate with a little native copper. The ore seems not to have been abundant.

The rock immediately north-west of Green Ridge between the State line and the Gettysburg and Chambersburg turnpike is a sandstone evidently F. I. no other rock appearing between Hughes's rolling mill on Cold Spring creek and Montalto furnace, on the south-west branch of Antietam. Further towards the north-east this sandstone constitutes only the south-west part of the mountain. At Caledonia furnace, on the Chambersburg turnpike, it is confined to the two narrow ridges lying west of the furnace, while the whole of the rocks south-east of this, as far as Green Ridge consist of the red and grey siliceous strata with their included greenish slates.

Crossing the mountain between Caledonia Furnace and Cold Spring, a distance of seven miles, in a S. S. E. direction, no vestige of the white arenaceous sandstone of F. I. was seen, until the foot of Green Ridge, at Cold Spring, was reached. The section displays rocks precisely similar to those on the east side of the mountain, on the rail road at Maria Furnace and at Holms's creek, showing every where marks of alteration by igneous action. In the ridge west of Caledonia Furnace, occurs a talcose sandstone; and a fourth of a mile south of the furnace, a highly altered, jaspery slate. Half a mile south of the furnace, we meet a grey, spotted, siliceous rock, evidently an altered sandstone; two miles south of the furnace, a grey, altered, siliceous rock, with dark blotches; and two miles north of Cold Spring, a greenish slate, spotted with epidote, and charged with much white quartz. One mile north of the same place, a reddish slate, speckled white, occurs; and half a mile nearer Cold Spring, is a red, jaspery, altered rock; all belonging, probably, to the thick system of slates composing the upper member of F. I., but greatly modified in texture by the intrusion of quartz and other igneous matter. Throughout this section, the strata dip invariably to the south-east. Though no anticlinal axis is visible, there is convincing evidence that the rocks have been upheaved along such an axis, and folded together, so as to make those on the north-west dip in an *inverted* attitude to the south-east—a feature very common throughout the whole range.

The mountain gap of the Gettysburg and Chambersburg turnpike divides the altered slaty rocks on the south from the unaltered sandstone on the north, until in our progress eastward we reach Newman's near the summit, east of which the altered rocks cross the road, to range north-eastward along the southern ridges of the mountain. The sandstone ridges which constitute the north-western spurs of the mountain, near Caledonia Furnace, jutting towards Green village and Shippensburg, ranging north-eastward, become the main body of the mountain, the *altered* rocks lying on the southern side. The same bed of altered rocks which lies between Caledonia Furnace and Cold Spring, and which crosses the turnpike south-east of Newman's, is seen on the southern side of the mountain, crossing one of the head waters of Conewago creek.

Crossing the mountain by another section further to the north-east, we find the following order of things. Beginning at Cumberland Furnace, and passing to the head waters of Opossum creek, the north-western ridges of the mountain, near Cumberland Furnace, consist entirely of the sandstone of F. I. In the ridge north of Pine Grove, the rock is a more talcose sandstone, belonging probably to a higher part of the formation. Large veins of white quartz are here abundant. A whitish talcose slate rests conformably upon the talcose sandstone, dipping with it to the south-east. This latter rock forms an admirable material for the in-walls of a furnace, and is used in that at Pine Grove. Immediately south of Mountain creek, near the furnace, occurs a thin interposed belt of limestone, used as a flux, and also taken across the mountain, into Adams county, for lime for the fields. This rock contains disseminated crystrals of *fluate of lime.*

Associated with this limestone, is a valuable deposite of *iron ore*, which has supplied the furnace here for a long time. It is of the kind usually found in our limestone soils, being technically the *brown hydrated proxide*, having a variety of structures. The *analyses* given in Chapter VI. displays the composition of one variety of the ore of this mine.

The limestone is evidently one of the interpolated beds common in the upper division of F. I. Passing the low ridge containing the limestone, we encounter a bold mountain of somewhat talcose sandstone, two miles in breadth, containing probably an axis of elevation with the rocks on its northern side *inverted*. On the southern flank of this ridge occurs a belt of altered siliceous rock, including a narrow band of talcose slate; and south of this, a zone of green altered slates, charged with epidote and quartz; and overlying this again, another belt, of a more siliceous altered slate. It is interesting to observe the importance which a single belt of limestone will give to a locality. It has here given rise to a rich deposite of *iron ore*, rendering productive a most beautiful and sequestered spot in a chain of hills, elsewhere remarkable for their forbidding features and sterile soil. The calcareous rock is only developed, to any extent, near the furnace, though it is said to be visible at Dull's saw-mill three miles higher up Mountain creek.

Another section across the mountain, still more to the north-east, extends from south to north along the Baltimore and Carlisle turnpike. The first important stratum of the hills is the usual grey siliceous altered rock so common along their southern side. North of this, about three miles from Petersburg, occurs the dark green slate, with its epidote and white intrusive quartz. Succeeding this, is an extremely compact, siliceous altered slate; and beyond this, a reddish grey rock, of the same series, containing specks of reddish felspar and small veins of epidote; and near this, the fissile talcose rock, several times mentioned before. North of these, we pass a tract of low ground, and then a high, rough ridge of sandstone; ascending which, we come to Mountain creek, at Holly Furnace—not now in operation. Beyond this to the north, is another bold ridge, the northernmost of the chain, consisting also of the white sandstone of the lower division of F. I., which here resembles closely the same rock as it occurs in Chicques ridge, on the Susquehanna. The beds here have a steep southern dip, of about seventy degrees. This dip is evidently, however, an *inverted* one, as these are the *lower* rocks of the formation, and lie north of the proper position for a folded or anticlinal axis. Between the northern base of this ridge and the margin of F. II., the limestone of the Cumberland Valley, a deep deposite of diluvial matter hides from our view nearly the whole of the slaty or upper division of F. I.; which, in consequence of its easy denudation, is commonly found in the valley at the foot of the mountain, thus covered by transported matter.

The north-eastern termination of the mountain, near Dillsburg, consists entirely of the lower sandstone, the altered slaty belt on the southern side having disappeared between the Petersburg and Carlisle turnpike and the end of the mountain, in consequence of the subsiding of the axis of elevation. It ends in two principal ridges. In a rough valley between these, occurs a yellow porous sandstone, often indicative of *iron ore*, some of which was found on the surface near the end of the southern ridge. A little north of Dillsburg, the limestone of the Cumberland Valley folds round the eastern end of the mountain, and appears on Dogwood run, south of Yellow Breeches creek, where it is covered by the overlapping rocks of the middle secondary series, consisting here of the calcareous pudding-stone, or Potomac marble, and altered red shale and red sandstone.

CHAPTER II.

Sketch of the operations of the Survey in the North-eastern Appalachian district, or that, lying between the South mountain and the Allegheny mountain, and between the Delaware and Susquehanna rivers, embracing the Anthracite coal fields.

The investigations in this district during the past year consisted of numerous detailed examinations in the southern coal basin, resulting in the developement of new and clearer views respecting the position of the coal in many important tracts. Many valuable local facts were ascertained, tending to give a truer insight into the structure and resources of this great coal field. By an extensive and laborious comparison of these, we have been enabled to delineate the outcrop of the principal important coal seams, upon our enlarged geological maps of the region, and to represent, as far as ascertainable, the relations of the beds beneath the surface, in an extensive series of sectional drawings. These sections, compiled from measurements as exact as could be made or procured, will furnish in conjunction with the maps when completed, a picture of the position of the coal throughout the several basins: rendering plain, many intricate features which no mere description, unaided by them, could make intelligible. The total number of sections at present drawn, displaying the situation of the coal, amounts to about one hundred and twenty. I am happy to state that the map intended to exhibit, on a large scale the topographical features of the several coal basins, and as nearly as practicable the range of the coal, is in a condition of considerable forwardness, though from the excessive complexity and truly wide extent of our anthracite region, much research will yet be necessary in order to complete it.

Having in my last annual report described with sufficient precision the approximate boundaries of the coal measures, in the numerous lesser basins into which the whole region is subdivided by a series of nearly parallel lines of elevation, and conceiving it injudicious, nay, wholly impracticable to enter at this time upon any local and partial details, which if published, could not be intelligible without the map and drawings, and which in their most compressed form would swell this report to more than twice its present bulk, I shall postpone a particular description of the district and refer the reader to my final and general report, which I confidently hope to finish in about two seasons more.

While carrying out the train of research begun during a previous season, in the several anthracite coal fields, attention was also especially directed to a subject which at present claims a high share of importance in connection with the resources of this portion of Pennsylvania. The application of anthracite coal in the process of smelting iron, first made in Wales, and recently introduced with entire success at Pottsville, by an enterprising citizen of the State, has called forth much inquiry as to the productiveness of our anthracite region in regard to ore.

I have therefore spared no pains to collect information bearing upon this important question, visiting and causing to be visited, particularly in the Pottsville region, every locality promising to be valuable in regard either to the quality or quantity of the mineral. Out of a variety of specimens collected, as great a number have been analized as the limited time allowed for the preparation of an annual report would permit. These have been selected with a view to show particularly the prevailing quality and average richness of the ores of the region generally. Especial care has been therefore taken to submit to chemical examination, such specimens only, as represent the average character of their respective beds, choosing those freshly opened in the mines or in some deep excavation, and rejecting as far as possible, samples gathered from the outcrop or found loose on the surface, as these invariably contain *two high* a percentage of iron, to prove a fair criterion. The results of the chemical examination of these ores will be found detailed in chapter VI. of the present report. While making these explorations, information on the subject was freely imparted to the proprietors of the lands, or mines, respecting their own deposites and a number of chemical analysis of their ores were presented to the owners with a view to guide them in their search.

The same views of utility which induced us to direct a share of our attention to the geological and chemical relations of the iron ore in the anthracite coal region have led us to explore both recently, and in previous seasons the district in search of limestone, valuable in many of the arts, but indispensable in that of making iron. Careful analysis have therefore been made of all the more promising calcareous bands appertaining either to the coal measures themselves, or to the lower formations situated outside of their boundaries. We have yet found no calcareous bed within the coal fields with a sufficient proportion of carbonate of lime to justify its use as a flux for iron. The mottled calcareous layers which occasionally occur in the upper beds of red shale F. XI. on the side adjacent to the conglomerate that underlies the coal, have also been subjected to chemical trial, the results of which made upon the purest of these yet found will be included in the final chapter. I have also recorded an analysis of the limestone F. VI. which ranges through the Orwigsburg valley south of the Pottsville coal basin, deeming it the nearest belt to the coal measures, pure enough to be employed as a flux. With the same view an analysis is given of the limestone F. II. of the region south of the Blue mountain, the variety examined being procured adjacent to the Schuylkill, about nine miles north of Reading, and being the kind now successfully employed in the blast furnace at Hamburg.

The amount of ore in each of the several coal basins of the anthracite region being evidently very great, and sufficiently ample should the quality be found proportionately good to contribute materially towards the supply of the numerous large blast furnaces likely to be erected in and around these coal fields at no distant day; it is not necessary in the present early state of researches on this subject to attempt a discription of the localities already developed. Besides being too burthensome for an annual report not furnished with the drawings necessary to explain them, these particulars respecting the ore would be of only very transient interest, inasmuch as every month is bringing to light many new deposites and altering the aspect of those already opened. I have thought it judicious, therefore, to submit at present only the chemical part of our examinations, as detailing the species of information which is at this time of more general and immediately practical interest. It was my intention to offer more than twice the present number of analysis of ores found in the anthracite coal measures, but the accidental miscarriage of a large box of specimens collected at a number of localities, has interfered with the design.

At this period when to all appearance, anthracite is about being extensively applied to the manufacture of iron, it is important that the composition of this invaluable combustible should be adverted to, for success in using it must much depend upon attention to the peculiar properties which distinguish it from other varieties of fuel. I have therefore deemed it desirable to accompany the analysis of the ores of the region with the results of similar experiments upon the coal, placing in the same chapter for the purpose of comparison, the chemical constitution of a number of coals from other districts in the state.

After prosecuting, during the early half of the season our examinations among the coal measures, and obtaining as much local information as practicable concerning the localities of iron ore, developed in the various recent excavations or in natural exposures, a portion of our attention was given to the geology of the valley north of the Blue or Kittatinny mountain. This belt of country was minutely explored from a point some distance east of the Little Schuylkill, westward to the Swatara, and a detailed map of its topography exhibiting the true position and range of its numerous and somewhat intricately distributed formations was at the same time constructed. This map will be extended hereafter to embrace the whole belt of country lying north of the Blue mountain, from the Delaware to the Susquehanna, and be connected if our time will permit with the general map of the coal region.

CHAPTER III.

Sketch of the Geology of those parts of the Third or South-Western Appalachian District, examined during the last year, embracing the counties of Cumberland, Franklin, Mifflin and Huntingdon, a portion of Bedford, with a part of Union, and a small part of Centre.

Turning, now, to the district lying south-west of the Susquehanna, embraced between the South Mountain and the base of the Allegheny Mountain, I shall, in presenting a general sketch of the geological structure and resources of the portions last explored, commence with that portion of the Great Kittatinny Valley, which includes the counties of Cumberland and Franklin, and which in this State is commonly called the Cumberland Valley.

SECTION I.

Of the Rocks of the Cumberland Valley, embracing Formations II. and III., with their associated Iron Ores, &c.

In describing the formations of this valley, we shall commence, as usual, with the south-eastern belt, taking it up at its north-eastern end, and tracing it southwardly. This belt is the great limestone tract of the south-eastern half of Cumberland and Franklin counties, our account of which commences at the Susquehanna river.

Limestone F. II. in the South-Eastern half of Cumberland and Franklin Counties.

Resuming our section along the south-western bank of the Susquehanna, we find the southern margin of the limestone overlapped by the red shales of the *middle secondary series*, about two miles below New Cumberland, at the mouth of the Yellow Breeches creek, the limestone rising in a moderately elevated cliff, near the river. Near its contact, it has derived a reddish tinge from the overlying red shale; but a little further north, in Musser's quarry, it loses this strain, some layers presenting the aspect of a fine white marble, which, if thick enough to work, would be a valuable rock. The prevailing dip of the limestone here is towards the S. S. E., at an inclination of forty-five degrees. Near the mouth of the creek, the limestone contains a narrow belt of slate, visible occasionally for several miles up the stream, and extending, indeed, the whole way to Maryland, along the southern border of the formation. Above New Cumberland, the limestone is discernable along the water's edge, preserving its usual character and dip. About a mile above, the dip diminishes to thirty degrees south, and gradually grows less, until a little more than a mile below the rail road bridge, at Harrisburg, the strata become horizontal, indicating this as the position of a flat anticlinal axis. North of this, for about a fourth of a mile, they incline northward, at an angle not exceeding twenty degrees. We then find a flat synclinal axis, beyond which, for three-quarters of a mile, to the bridge, the steeper southern dip is resumed, gradually increasing, until at the bridge it is about fifty-five degrees. The steep southern dip continues to the boundary of the limestone and slate, or F. III., which is seen in the ravine at the bridge, along which the rail road passes. The slate here, dipping to the south or under the limestone, is evidently inverted by a folding of the rocks in the limestone belt, somewhere between this point and the synclinal axis above mentioned. The natural or original position of the great slate formation of the Kittatinny valley, is *above* the limestone.

From this point of junction near the bridge, the line dividing the two formations, ranges nearly westward to the most southern bend of the Conedogwinit creek; following thence the *general* course of that stream, the southern bends of which reach but do not penetrate the limestone, while its northern meanderings lie all in the slate. The limestone, towards its northern margin, contains thin belts of the slate, similar to that noticed as ranging near its southern side. Near Newville, the boundary leaves the course of the Conedogwinit, to bear somewhat more southwardly. It here makes a double turn, taking a zigzag course in consequence of an irregular anticlinal axis near Newville, which elevates the limestone in a long projecting point, penetrating the slate north-westwardly. Resuming its regular course, it passes south-west from Newville, leaving Shippensburg three miles to its south-east, and then deflecting still more towards the south, it passes a little west of Green village, and reaches the Conecocheague north of Chambersburg. It follows this stream past the town, and after pursuing it about four miles, stretches away in a S. S. W. direction to Greencastle, and thence on to the Maryland line, which it intersects about a mile east of the Conecocheague.

The southern margin of the limestone leaving the Susquehanna two miles below New Cumberland, runs first north-westward, and then westward for several miles, leaving a narrow belt of the rock on the south side of Yellow Breeches creek. The overlapping red shale crossing the creek about two miles north of Lisburn, follows its border to Bryson's, west of Lisburn, where the red shale leaves the limestone, the formation beyond this point being bounded on the south by the rocks of F. I. Making the general course of the creek its margin, the limestone passes by the south side of the stream, at Williams's mill, about three miles north of Dillsburg, and extends some distance along Dogwood run, folding round the end of the South Mountain.

Further towards the south-west, the edge of the limestone lies near the north-western base of the mountain, though it is frequently concealed by a covering of diluvium. In some places, owing to a fault or sudden folding together of the slate of F. I., immediately at the base of the mountain, the limestone approaches the sandstone, and indeed in some of the ore banks, situated low down on its declivity, limestone shows itself beneath the ore. In these instances, however, it is probably not the main body of the formation, but a narrow belt in the slates of F. I. The limestone, generally, is much interstratified with greenish and reddish slate along the base of the mountain.

Having thus defined, with sufficient accuracy, the two boundaries of this broad tract of the limestone, I shall next notice some of the details connected with the formation most deserving of description in this place, leaving the minute and systematic delineation of the whole for the pages of my final report. Proceeding westward from the Susquehanna, we meet with a deposite of good iron ore, about two and a half miles from the Harrisburg bridge, on the farm of W. R. Gorgas. The ore is imbedded in the ferruginous soil which overlies the limestone. It occurs in bunches and irregular veins, the general direction and dip of which coincide somewhat with those of the underlying limestone. It is conveyed by the rail road to the river, and thence by the canal to the furnaces above Harrisburg. It is the usual brown ore, and is of a cellular structure. The analysis in chapter VI. will show its average composition.

A trap dyke crosses the Yellow Breeches about two miles north of Lisburn, altering, more or less, the adjacent limestone. In the vicinity of Sheperdstown, three miles south of Mechanicsburg, the limestone encloses a considerable tract of slate, rather more than half a mile in breadth. This slate is probably a portion of F. III., folded in between the limestone in a compressed synclinal axis. About a fourth of a mile north-west of Sheperdstown, iron ore, apparently of good quality, has recently been obtained. It has not thus far proved abundant, though little has been done towards developing it. At the Carlisle Iron Works, six miles S. S. E. from Carlisle, a trap dyke, issuing from the mountain, crosses the Yellow Breeches creek immediately at the furnace, and extends north twenty degrees east, entirely across the valley, meeting the base of the Kittatinny or North mountain about two miles east of Sterrett's Gap. It forms a sharp, very narrow, rocky ridge, from ten to seventy feet high—a useful natural boundary employed to designate the township lines. The limestone is considerably affected by it in its texture and color, though not much disturbed in its prevailing south-eastern dip. In a quarry near the furnace, a little removed from the trap, the rock has the aspect of fine grained, whitish, and dove colored marble. This trap dyke, and the contiguous beds of the limestone, are well seen in the cutting on the Harrisburg and Chambersburg rail road, where the dyke is about sixty feet wide. Another lesser trap dyke penetrates the limestone a little westward of the former.

The ore which supplies the Carlisle Iron Works is obtained at several points. One variety, denominated "mountain ore," occurs along the northern slope or base of the first sandstone ridges, near the junction of the limestone. Another variety, known as limestone or *pipe ore*, belongs to the ferruginous soils overlying the limestone itself. The iron obtained from the mountain ore is generally "cold, short," hard and brittle; while that derived from the limestone ore is softer, tougher, and more tenacious. The mountain ore is in some furnaces employed alone for the manufacture of foundry pigs and castings, but a mixture of the two kinds is generally deemed necessary for the production of good cast iron for forging. One principal reason of this is, that in the mountain ore derived originally from the strata of F. I., the oxide of iron is associated with a larger proportion of the oxide of manganese, and other deleterious constituents, than generally accompany it in the ores of F. II., originating from a different source. Both of these varieties belong to the general species called by mineralogists, brown hydrated iron ore, though they assume a considerable diversity of aspect and structure, arising from their greater or less degrees of richness and purity, and the manner of their concretion.

The mountain ore, obtained a mile and a half south-west of the Carlisle works, is of several descriptions. In the upper portion of the deposite, much of it is compact, passing under the name of "hard ore." The "honey-comb ore," lying beneath this, or imbedded between it, is a softer and more porous variety, more readily reduced in the furnace. Half a mile south from the furnace, a small body of a somewhat different ore has been met with.

The "limestone ore" employed at this furnace, is obtained from a belt about two miles N. N. W. from the works, where ore has been dug, in different places, for several years. The present supply is chiefly from a deposite about eight feet thick, reached by a shaft from sixteen to twenty-five feet deep, Much of it belongs to the fine variety denominated "pipe ore," consisting of a congeries of parallel stalactitic tubes or stems, from whence it derives its name. One part of this ore is mixed with two parts of mountain ore in the manufacture of forge pigs. For the chemical composition of these several ores, see chapter VI.

The limestone employed as a flux at this furnace is selected with a view to facility in procuring it, more than from a regard to its purity; some of the belts lying further north would be better adapted. Between the deposites of limestone ore above mentioned and Carlisle, ore is found in several places; an extensive digging, now abandoned, occurring near the Hanover road. Half a mile south of this, on a farm belonging to Mr. Holmes, a very good looking ore occurs, which has been more recently mined. Between this and Carlisle, other excavations exist, from whence the ore is conveyed across the North mountain to a furnace south of Landisburg, where it is mixed with ores of that neighbourhood.

In the neighbourhood of Carlisle, occurs much good limestone; both the ordinary kind, adapted for making lime, and the magnesian variety, suitable for the manufacture of *hydraulic cement*.

About four miles westward from Carlise, near the State road occurs a neglected excavation where iron ore to some extent has been procured. About four and a half miles south of the town near the turnpike, is a deposite of apparently good ore formerly wrought to some extent, to supply Holly furnace not now in operation. On the Walnut Bottom road about five miles south-west from Carlisle ore, is abundant on the surface of a little hill. Southward of this at Peffer's, between the foot of the mountain and the creek, ore was formerly obtained for Holly furnace, and more recently for Cumberland furnace. See Analysis, chapter VI. Though not far from the sandstone of the mountain, some of it is of the variety called pipe ore, characteristic of the limestone formation, parts of it however, are manganesian. Along the low ground, near the foot of the mountain, ore is abundant on the surface for a considerable distance westward.

Cumberland furnace, the property of General Thomas C. Miller, not in blast at the time of our explorations in the vicinity, has been smelting chiefly the ore obtained near the base of the sandstone ridge of the mountain about three miles south-west from the furnace. This ore appears to lie in bands, and large bunches or nests in the loose soil near the bottom of the declivity of the mountain. The mine chiefly wrought at present, is an irregular excavation, from thirty to forty feet deep, in the sides of which, the ore is scattered in lumps throughout a large extent of the deposite, but is best, and most abundant nearest the bottom. The ore from this bank is mixed with an ore from the limestone tract obtained a mile and a half north of the furnace. For an analysis of each of these ores see chapter VI.

Iron ore occurs on the surface about seven miles west of Carlisle on the farm of Mr. William Kerr, in considerable quantity. For the composition of this ore see chapter VI.

Near the Big Pond at the head of Yellow Breeches creek, we come upon Pond Furnace, owned by Mr. John Moore, worked by the hot blast and making foundry iron. The ore smelted at this furnace, is procured from F. I. on a low spur of the mountain, south-west of the Pond. The old excavation on the eastern side of the hill have lately been left and another deposite opened on the western side by a shaft which shows several feet of ore about twenty feet from the surface. The limestone employed as a flux in Pond furnace, is collected from the surface fragments of the neighbourhood and is therefore of every diversity of character. For an analysis of the ore see chapter VI.

Mary Ann furnace, the property of Messrs. Whitehill and Ellis, lies about three miles west of the Pond. Near it is Augusta furnace, belonging to the same firm. The latter is not in operation. These furnaces are situated close at the foot of the mountain, about three miles south-east of Shippensburg. Mary Ann furnace, now in blast is supplied with ore from two banks, one lately opened, called the "Helm bank," three miles north-east of the furnace, and another called the "Clippinger bank," two miles towards the north-west. The Helm bank ore overlies that part of the limestone which is much interstratified with slate, being near its margin. The ore is apparently about two feet thick, dipping steeply to the north-east, but varying much in quantity in different parts of the excavation. The Clippinger bank yields an ore of the very best description, much of it being stalactitic, or of the kind called pipe ore. The analysis to be found in chapter VI. will display the prevailing composition of the ores of both these banks.

The above Clippinger ore occurs in irregular nests in the interstices of the limestone rock, surrounded by a very tenacious reddish clay. The quantity fluctuates much in different spots and the water incommodes more or less the deep diggings. These circumstances attend nearly all the deposites of the limestone ore in the valley. Where the ore occupies the interstices between the beds of limestone, it is almost invariably pure and of the pipe ore kind, though the quantity in these situations is apt to be precarious. The mountain ore obtained near the junction of the limestone and the sandstone of the mountain and therefore, generally along the slaty or upper division of F. I. is procured with greater certainty, but is frequently quite unfit for making forge pigs without an admixture of the purer ore of the limestone, being used by itself only for foundry iron. The flux used in

Mary Ann furnace is a limestone procured in the vicinity of the Clippinger bank.

Southampton furnace is situated about three miles further to the south-west, or four miles south of Shippensburg. It belongs to Mr. Charles Wharton, of Philadelphia. The two furnaces in blast here are supplied with ore from these different banks. One called the "Hill bank," lying about three hundred yards west of the upper furnace, contains the mountain ore in its usual varieties. That in the upper part of the mine is hard and cold short while a honey-comb ore lying beneath it is of much better quality. The ore of this bank supplies the upper furnace which uses the hot blast and makes foundry iron and castings.

The lower furnace is furnished with ore from a mine at Kressler's, three-fourths of a mile to the north-west, and also from the "Rail Road bank," lying in the limestone formation, four miles west of the furnace. The ore at Kressler's has been extensively wrought for some years. It occurs in nests and irregular layers in the soil and rotten slate, which have a range and dip nearly coinciding with the direction of the underlying strata. This ore is esteemed well adapted for making good bar iron, but is less productive in quantity than some others in the neighbourhood. Much loose ore is visible on the surface north of the present excavation. The "Rail Road bank" formerly yielded a valuable supply of good ore, but the encroachment of the water and probably a reduction in the quantity of ore, have caused it of late to be less vigorously wrought. The ore exists rather in bunches or nests than in regular layers and is hence very variable as to quantity. A small ridge of limestone bounds the ore immediately on the north. The lower furnace, smelting these ores, makes forge pigs for bar iron, and uses the blast cold. For the *analyses* of these several ores consult chapter VI.

Proceeding northward to the neighbourhood of Shippensburg, a moderate amount of excellent ore has been procured in a spot called the "Pilgrim bank," near the northern margin of the limestone, three miles and a half from the town. A good ore was formerly obtained on the farm of Mr. Hamills, a mile and a half south-east from the town. Ore was also procured about a mile and a half west of Shippensburg, at the old Roxburg bank. It was the *stalactitic* or *pipe ore* and made a bar iron which was much esteemed for its soft and tough qualities, but as usual with ore of this description the quantity was limited. For *analyses* see chapter VI.

About two miles south-east from Greenvillage, and half a mile north of the rail road, a deposite of beautiful *pipe ore* of excellent quality, is wrought for the supply of Caledonia furnace, to which it is conveyed a distance of eight miles in wagons. It produces a good iron and with great facility, agreeing in these respects with the pipe ore generally. It occurs in bunches, which together form an irregular layer conforming with the direction of the adjacent limestone. Its position is between two little ridges of the limestone, one of which immediately bounds it on the north. It is deeply covered with earth and must be somewhat expensive to procure. For *analyses* see chapter VI.

Caledonia furnace, the property of Messrs. Stevens and Paxton, is situated on the Gettysburg and Chambersburg turnpike, ten miles from the latter place. It is supplied with ore from several deposites, besides the Greenvillage bank already noticed. A belt of ore ground extends apparently for several miles near the line of contact of the limestone of the valley and the sandstone of the ridges, which jut forward in advance of the main body of the mountain. On this line of ore, coinciding probably with the position of the crushed slates which intervene between the limestone and the sandstone, the Pond banks occur about three miles from Caledonia works. They consist of extensive diggings in which the ore is met with at various depths in nests and irregular layers included in a ferruginous soil, much of it has a hollow reniform structure. About three hundred yards south of this, a bed of ore was formerly wrought for the supply of Montalto furnace. It overlies the sandstone, and yields a metal of very indifferent quality. The flux employed in Caledonia furnace is procured a little north of the Pond diggings.

Another excavation furnishing ore for the same furnace occurs three miles further to the south-west, at Hiefner's. This bank situated further from the mountain than the former, yields an open and crumbly ore which smelts with facility but produces a somewhat cold short iron. The chemical composition of these ores will be found among the analysis in chapter VI.

In one of the openings at Hiefner's, an impure limestone was encountered thirty feet from the surface. A little eastward of the openings, some pipe ore occurs in the soil, for an analysis of which see chapter VI.

Another belt of ore ground seems to exist on the summit of a little ridge of limestone north of the former excavations. This ore is different in quality from the other and promises to be abundant twenty feet below the surface. The ridge extending southwestward, the ore seems to continue along it, and about three fourths of a mile from the Hiefner bank, occupies the surface in an abundance seldom seen. It has been partially opened here, but making a highly cold short iron has been abandoned. These deposites of ore seem to range nearly along the line of contact of the limestone, and a narrow interposed belt of siliceous slate and sandstone.

About a fourth of a mile south-east of Beattie's on the turnpike, occurs a dark colored limestone, an unsuccessful trial of which as a flux was made in the furnace. The *analyses* showing its composition will be seen in chapter VI.

Iron ore, of very inferior quality, occurs between two ridges of sandstone three miles N. N. E. of Caledonia Furnace; affording another evidence of the impure nature of the ores derived from the rocks of the South mountain, when compared with those which occur in the limestone of the belt immediately north-west of it.

Montalto Furnace, the property of Mr. Hughes, is situated on a branch of the Antietam creek, about seven miles north-east from Waynesburg, and near the foot of the outer sandstone ridge of the mountain. Though ore appears upon the surface, in more or less abundance, the whole way along the north-west base of the mountain from Ege's Carlisle works to this place, yet no where does it occur in such profusion as between the Caledonia diggings at the pond and a point two or three miles south-west of Montalto. This furnace is supplied from extensive excavations lying about a fourth of a mile north-east of it, on the declivity of the first sandstone ridge. The ore occurs, as in other similiarly situated mines, in the loose soil of the mountain side, in nests and irregular layers, varying greatly in their dimensions: but the whole deposite seems to be of prodigious magnitude. It is believed by the miners, that the body of ore in which they are now working is not less than forty feet thick and sixty or seventy yards wide,—including, of course, the feruginous earth between the bunches and veins or ore. The lower portion of the ore is the purest. This ore, so abundant in quantity, does not, however, yield a high per centage of iron. The furnace, seems to be a successful one, producing annually about eight hundred tons of metal, in the shape of castings and forge pigs for the use of two forges and a rolling mill, situated on the east branch of Antietam creek, five miles below the Cold Spring. The compositton of these two ores is recorded in chapter VI.

In one of the deeper diggings of Montalto, a band of limestone has been reached, being a layer probably in the slates of F. I. It is interesting to observe the connection between limestone rocks and large deposites of iron ore of the variety, called *brown hydrated per-oxide*.

South-westward from Montalto, much ore strews the surface along the north-western side of the mountain. In the neighbourhood of Tomstown, it occurs in large blocks, but is very silicious, being associated with fragments of the yellow silicious rock already alluded to as frequently accompanying the iron ore along the mountain.

The limestone folding round the southern end of this mountain ridge, extends some distance up the little valley of the Cold Spring branch, appearing on the north side of Green Ridge below the rolling mill. *Iron ore*, in moderate quantity, but of inferior quality, has been dug to some extent on the north-west side of the stream. The *analyses* exhibiting its chemical nature may be seen in chapter VI.

A considerable amount of ore is visible in the soil on the farm of Mr. Middauer, three miles north-east from Waynesburg. It promises to be rather too silicious to make a superior iron. For *analyses* see chapter VI.

On the southern part of the same farm, and also on another adjoining one, loose masses of tolerably pure white sulphate of baryta occur. It probably occupies a position between narrow belts of limestone and slaty sandstone, which traverse the hills of this neighbourhood.

Proceeding from the foot of the mountain towards Waynesburg, after leaving the low grounds, we first meet with slaty limestone, alternating for some distance with slate, until we reach the second ridge, three miles south-east from Waynesburg, where a band of white limestone crosses our section. This latter rock is quarried, and shaped into tombstones, about three miles further south west. On the top of the ridge, the limestone is of a dark color, alternating over a breadth of a mile with bands of slate. In the next ridge, two miles south-east of Waynesburg, the limestone is interstratified with a thinly laminated green slate. Near Waynesburg, the slate becomes more silicious, some of it being reddish, and nearly all of it containing minute scales of mica.

The line of iron ore seems not to extend south-westward much beyond Midduer's; for in crossing its range in several places between Waynesburg and the foot of the mountain, few indications of ore were visible on the surface.

On the southern branch of Antietam creek, near the Maryland line, we again encounter the band of white limestone at Royer's. The bed is several feet thick, but somewhat divided by thin sheets of a greenish slate. It is a beautiful rock, of a white aspect and fine texture, and where large blocks are not required, might be advantageously employed as *marble*.

A rather extensive cavern occurs in the limestone at the north-eastern end of the ridge, a little lower down the same branch of Antietam creek. Lower down the stream, at David Funk's, occurs a grey calcareous and silicious rock, in thin layers, from which excellent flag stones are quarried. Still further down, and near the State line, is a belt of limestone, said to yield a lime which will not slake after being burned.

Near the west branch of Antietam creek, one mile north-west of Waynesburg, is a deposite, of considerable superficial extent, of *travertin* or *calcareous tufa*. A similar deposite is visible near the mill east of Chambersburg, and in several other places along the streams of the limestone region, where the water is highly charged with carbonate of lime. This material, when in a sufficient pulvelerent condition, is an admirable manure, particularly when applied in compost.

The north-west border of the great limestone belt passes through the borough of Chambersburg, in the neighbourhood of which some bands of the rock are *fossiliferous*,—a character which the formation rarely assumes any where in the Kittatinny valley north-eastward of Franklin county.

About seven miles southward of Chambersburg, in a ridge called "Grindstone Hill," we find a bed of sandstone, interstratified with the limestone, yielding a material suitable for rough grindstones.

Advancing from Waynesburg towards Greencastle, we cross alternating belts of limestone and interstratified greenish slates; and beyond these, the limestone, is nearly uniform over a considerable breadth of surface, diversified as usual, however, in color, composition, and properties. Four miles north-west of Waynesburg, occurs a dark bituminous variety; and in a ridge two miles further, a band nearly white. Immediately north-west of Greencastle, we encounter the line of contact of this wide belt of F. II. and the slates of the base of F. III. This latter rock, to which we shall next proceed, ranges along the north-western margin of the above zone of limestone the whole distance across the State from the Delaware river to this point, and southward into Virginia.

Of the Great Slate Belt F. III. of the Cumberland or Kittatinny Valley.

The uniform character and composition of this wide formation, together with its general deficiency in interesting and useful minerals, will render a detailed description of it unnecessary in the present place. Its south-eastern margin has been indicated in defining the north-western boundary of the limestone. From the Delaware Water Gap to Strasburg, in Franklin county, its north-western limit coincides with the base or flank of the Kittatinny or North mountain, where it supports the massive sandstones of F. IV. occupying the summit of the ridge. From Strasburg to the Maryland line, the slate recedes from the mountain, and is bounded on the west by a wedge-shaped tongue of limestone, the limit between the two rocks passing the villages of Strasburg and St. Thomas or Campbellstown, and intersecting the Maryland line about a mile west of Conecocheague creek.

About a mile and a quarter from the base of the mountain, at the Susquehanna river, the slate includes a thin belt of limestone, imperfectly visible at the river's side. Either the same or another bed is seen about a fourth of a mile nearer the mountain. This belt seems to extend westward several miles,—growing, however, gradually thinner and more slaty, and ceasing, probably, south-east of Sterret's Gap.

In no part of the slate formation have we found the strata possessing the structure and cleavage requisite to produce *roofing slate*. The nearest approximation to that useful variety which we have yet seen, occurs in the bed of the Conedogwinet, above Alter's mill, where the rock is traversed by cleavage plains of tolerable regularity, but is destroyed from usefulness by containing *sulphuret of iron*.

At "Dublin Gap," north of Newville, their occurs a spring highly charged with sulphuretted hydrogen; an analysis of which, together with that of other mineral waters, will be given in a future publication.

Some bands of the slate, particularly those lying adjacent to the limestone, are highly carbonaceous and of a dark color, resembling somewhat the slates of the coal measures. This analogy in their appearance, notwithstanding the conclusiveness of all geological evidence to the contrary, induces many persons, not familiar with our stratification, to suppose that the formation may actually embrace *coal.* Excavations have from time to time been made, therefore, at various places in the valley for the last fifty years, in the confident belief that coal would be discovered, and though in every instance unsuccessful, we find them still occassionally renewed.

Of the Belts of Slate and Limestone in the South-Western part of Franklin County.

The south-western portion of Franklin county contains three moderately broad belts of limestone, alternating with three belts of slate, occupying the interval from the margin of the great slate formation above described to the eastern slope of the Cove mountain. An anticlinal axis ranges nearly centrally along each zone of limestone, imparting to the intervening belts of overlying slate a regular synclinal structure. The most eastern, and by far the largest, range of limestone, is that already alluded to as terminating in a long tongue near Strasburg. It is broadest at the Maryland line, and does not materially diminish in width until we trace it about three miles north of the Greencastle and Mercersburg road, where it is about three miles wide. West of St. Thomas, it is but little more than a mile from its eastern to its western border, which is within three-fourths of a mile of Parnell's knob. Here it curves a little eastward, taking a direction about N. N. E. to Strasburg, following the foot of the mountain until it disappears in a narrow point under the overlying slate. The anticlinal axis which runs somewhat centrally along this belt, prolonged beyond Roxbury, seems to extend for many miles towards the north-east, being probably the same axis which separates the North mountain, at Dublin Gap, from the spur lying south of it, and which is thence prolonged through Perry county.

The usual aspect of this limestone is rather uniform. The beds belong to the upper half of F. II.; some of those in the southern part of the tract, near the anticlinal axis, being magnesian, and well adapted, therefore, for furnishing *hydraulic cement.* About five miles north-east of Mercersburg, and two and a half miles from St. Thomas, not far from the anticlinal axis, lies a deposite of iron ore, no longer wrought. It is stated to have yielded a good, soft iron; it was, however short or brittle at a welding heat. When roasted or smelted, it gave off a strong odour of *garlic*,—a circumstance indicative of its containing arsenic. The presence of arsenic in this ore I have ascertained by analysis, the results of which, showing its chemical composition may be seen in chapter VI.

The belt of slate which bounds this tract of limestone on the west, embracing both sides of Claylick mountain, at the Maryland line, ranges a little east of north to the foot of Parnell's knob, where it again separates by receiving the mountain in its synclinal axis, one portion passing along the eastern and the other along the western base and slope. The overlying sandstone beds of F. IV., occupying the tops of Claylick and Parnell's mountains, in the middle of the trough of slate have a nearly perpendicular dip, implying that they have actually been folded together, along the sinclinal axis, by an action like that of closing a book with its back or cover downwards. West of this belt of slate, the average width of which somewhat exceeds a mile, there ranges a narrower zone of limestone, belonging to F. II., traversed longitudinally by an anticlinal axis, which has lifted the limestone to the surface, and given to the rocks east and west of it the steep inclinations which they possess. This anticlinal belt of limestone, passing out of Blair's valley, between the Claylick and Two Top mountains, at the Maryland line, ranges to the mouth of Bear valley, separating Parnell's from Jordon's knob. Its average breadth is about half a mile. The rock exhibits the usual variety in its several beds, some of which are siliceous, while others again are adapted to produce an excellent pure lime by burning. Certain bands of it are evidently of the kind suitable for hydraulic cement. About a mile and three-quarters from Parnell's knob, the soil above this limestone contains a deposite of iron ore, smelted in the small furnace at Louden,—which was not, however, in operation during the past summer.

West of the last described belt of limestone, ranges another parallel zone of the slate, also about half a mile in width, which, like the former mentioned tract of slate, contains a synclinal trough, in the middle of which lies the Two Top mountain on the south and Jordan's knob on the north.

To the west of this slate ranges another anticlinal belt of limestone, emerging from between the Two Top and Little Cove mountains south of the Maryland line, and ranging along the foot of the latter to Louden, and thence for several miles along the middle of Path valley, vanishing in a narrow point north-west of Fannetsburg. The elevation of this belt of limestone has caused the eastern inclination of the rocks in the Two Top and Jordan's mountains, and the western dips in the Little Cove and Tuscarora ridges. We thus perceive that all the vallies subordinate to these axes of elevation contain the limestone or its next superior rock, the slate, having in every case anticlinal dips; while the mountain ridges included between these vallies, consisting of the higher stratum F. IV., rest invariably in the synclinal troughs embraced between the lines of elevation.

On the west side of the last described tract of limestone, about four miles west of Louden, a deposite of iron ore occurs, formerly smelted in the old Mount Pleasant furnace near it, but now taken to Carrick furnace, four miles towards the north. The ore ranges, in greater or less abundance, for six or eight miles, in a narrow line along the south east base of the Tuscarora mountain, being procured in considerable quantity north of Carrick Furnace. Its position is near the contact of the limestone and overlying slate. It is of two varieties; one a hard ore, occasionally iridescent, making a rather cold-short iron; the other a "honey-comb ore," esteemed of much better quality. The analyses, showing their chemical nature, may be found in chapter VI.

The limestone employed as the flux in Carrick furnace, is procured in part from a quarry adjacent to the works, and in part from the loose pieces scattered through the neighbouring fields. A little *pipe ore* has been occasionally found.

The narrow belt of slate which overlies the last mentioned range of limestone, occupies the base of Little Cove and Tuscarora mountains, rising nearly to their summits where it supports the sandstone rocks of F. IV. Passing west of Londen and Fannetsburg by Concord, it extends into North Horse valley, between the Tuscarora and Conococheague mountains in Perry county.

The valley called the Little Cove, bounded by the Cove or Tuscarora mountain on the west, and the Little Cove mountain on the east, presents the strata in a synclinal or basin-like position, the two enclosing mountains consisting of the sandstone F. IV. Both margins of this valley are occupied by the red slates of F. V. seen near the foot of the bounding ridge. The limestone F. VI. encircles the Cove, inside of the red shale supporting in its turn F. VII. is two belts, the north-western ore forming a considerable ridge. The centre of the basin is occupied by the slates of F. VIII. the strata on the west side of the synclinal axis, dipping gently east, while those on the east side are nearly perpendicular. Among the bottom layers of this slate, occurs a highly important bed of iron ore used at Warren furnace. It is a grey *proto-carbonate of iron*, precisely identical in chemical composition with the nodular and plate ores of the shales of the coal measures. The discovery of the true nature of this ore and of the exact place which it occupies in the strata, I regard as among the most useful of the developements of a practical kind made by us during the past year. I shall have occasion in describing the rocks of Huntingdon and Bedford counties, to allude again to this important deposite. Among the analysis in chapter VI. will be found that of this ore as it occurs in Little Cove.

SECTION II.

Of the Rocks of the Lewistown and Aughwick Vallies and their prolongations, embracing the belt of country extending from the Susquehanna river, to the Maryland line, and bounded on the south-east by the Shade, Black Log and Cove mountains, and on the north-west by Jack's mountain and Sideling Hill.

Lewistown Valley.—Adhering as far as practicable to the order of description adopted for all our formations, I shall proceed to the next most south-eastern belt explored, and trace it from the north-east towards the south-west. For convenience sake I have ventured to give the name of Lewistown Valley, to the belt of country embraced between Jack's mountain and Longstown ridge on the north-west, and Shade mountain and its prolongation, the Blue Ridge, on the south-east, extending the title to the whole of this well marked valley, from the Susquehanna to the Juniata, at Jack's narrows.

A series of narrow, nearly parallel ridges of inferior height to the bounding mountains divides the general valley into several lesser ones, known by distinct appellations. Thus, a transverse line through Adamsburg, from Shade mountain to Jack's mountain, crosses three separate small vallies. That on the south-east, being the fertile limestone valley of Adamsburg, Beavertown, and Middleburg, that in the middle being the valley of Black Oak ridge, and that on the north-west, the fertile valley known as Moser's valley. These are all traceable to the Susquehanna. The Blue Hill at Northumberland, is a continuation of the Black Oak ridge, while Dry valley containing the town of New Berlin, is but a prolongation of Moser's valley. Along the Bellefonte and Lewistown turnpike, we observe first, the valley, in which Lewistown is situated, beyond this to the north-west another called Dry valley, which terminates a few miles north-east of the turnpike and beyond this again between the limestone ridge at Rawle's forge, and the foot of Jack's mountain, a third, known as Little valley, prolonged to the south-west of the turnpike under the name of Ferguson's valley and Long Hollow.

Formations. The mountain ridges which bound the belt on the south-east and north-west, are composed of the fourth formation of one lower secondary series, divided in my former annual reports into three distinct members. In Shade and Jack's mountains, the lower division of F. IV. is a hard compact sandstone of a greenish hue with some beds of a whiter variety, containing in its superior portion, layers of a reddish coarse conglomerate. The middle division is a red argillaceous sandstone, speckled with yellow *hydrated peroxide of iron.* The upper division is a compact sandstone of several shades of color, white prevailing, jointed into large massive, angular blocks. This last part of the formation usually forms the highest ridge of the mountain, the lower division occupying a bench on the flank of the mountain, often one-third of its height from the summit. In Jack's mountain, these lower rocks form the bench along the south-east side of Kishicoquillas valley, but in Shade mountain only the upper member of F. IV. can be observed, the anticlinal dip of the strata placing it upon the flanks of the ridge, which for most of its length consist of three parallel summits, the central one being constituted of the lower sandstone member of the formation. The whole thickness of F. IV. as it occurs in these mountains is probably about fifteen hundred feet.

The hard grey sandstone of F. IV. graduate by a series of alternations with layers of compact red sandstone into the red and variegated shales of F. V. This last important stratum, together with the limestone F. VI. which it supports, constitutes the most fertile and valuable tracts of the general belt before us. Besides, containing bands of compact and good limestone; F. V. includes in its upper division, which is several hundred feet thick, a soft calcareous shale which readily disintegrates and forms one of the richest soils of the State. The alternating red and grey sandstones at the base of the formation, are sometimes argillaceous, when they can be split and shaped into excellent flag-stones. Some of these abundantly covered with the fossil remains of the marine vegetation, called *fucoides* h been much employed for the side walks of the streets of Lew town.

The next division of F. V. is highly argillaceous. The hills co posed of it constituting a peculiar feature in the topography not on of this valley, but of the whole district to be described. The low layers consist of a thin argillaceous brown sandstone, full of the r mains of *trilobites*. These support a thick mass of olive and b colored shales, highly fossiliferous, and upon these reposes a san stone of variable thickness, but of well marked characters, demandi particular notice, as furnishing our best guide to the exact position the *fossiliferous iron ore*, which confers so much interest upon V. in an economical light. This sandstone and the ore invariab occur in close proximity to each other. The prevailing aspect the stratum is that of a rather coarse grained, dirty white and yellowish sandstone, containing fragments of *Encrini* and other fossils. I frequently constitutes a small ridge of itself. It may be studied in a fine exposure south of Simon Gros' house, near Shade mountain. It is exposed in many other places, as at the north base of the chain of slate hills, south of Adamsburg and the slate hills, one and a half miles south of Middleburg, where large detached fragments of it abound. These present upon their surface, numerous impressions of *terebratula* and other fossil shells. The *fossiliferous ore* usually rests almost immediately over this bed of sandstone. Above the ore reposes a series of olive and green shales supporting the limestone layers of the formation. Between the Susquehanna and the Lewistown turnpike, these bands of limestone are generally argillaceous or siliceous, and therefore rarely furnish pure lime.

Above the limestone occurs the main bed of red shale and sandstone of the formation, in some places including very hard bands of green and reddish sandstones, breaking into cuboidal fragments. Ascending the red shale becomes calcareous and alternates with a soft greenish variety which is decidedly calcareous, containing indeed towards its upper portion some thin bands of limestone. This part of the formation is about five hundred feet thick in the vicinity of Lewistown, and furnishes much of the richest soil of the valley. The total thickness of the entire formation is apparently between three and four thousand feet. It occurs along the base of the mountains, forming the hills immediately adjacent to them. It likewise constitutes a belt in Little valley, Dry valley, Moser's valley and the valley of Middl creek.

Overlying the shales of F. V. is the valuable limestone F. VI. o our series. This is the rock of all the limestone ridges throughou the valley. The lower beds are too argillaceous and slaty, to produc good lime, but those higher in the formation supply it of great purity Near the top of the stratum are bands of very siliceous limestone abounding in fossils and layers of compact *chert*. This upper division of the rock is frequently too siliceous to be converted into lime The bed of *chert* is of variable thickness, being sometimes twen feet in depth while sometimes it is wholly missing. Its position is generally on the tops and sides of the limestone ridges, its angular fragments covering the surface. On the road from Adamsburg to Shroyer's, it is thirty feet thick.

Immediately resting upon the chert or removed from it but a short distance, are the loose and porous layers of yellow sandstone at the bottom of F. VII. The whole stratum appears to thin out towards the Susquehanna, for here we find only a trace of it, while on the Lewistown turnpike at the toll gate it is seventy feet thick, presenting itself on the surface as usual in massive blocks full of the cavities left by the dissolution of its fossils. The bed itself is not distinctly traceable more than twelve miles north-eastward from Lewistown, but fragments of the rock are seen adjacent to the limestone, at intervals the whole way to the Susquehanna, implying however, that it either is not continuous or is very thin. This sandstone caps nearly all the limestone ridges of the valley from north-east of Lewistown, to Huntingdon county.

Supported by the sandstone beds of F. VII. is a thick mass of slaty rocks, which constitute F. VIII., forming some of the ridges of the central part of the valley; for example, filling a large part of Black Oak Ridge valley to the Susquehanna. The lower part of F. VIII., near its contact with F. VII., sometimes contains a coarse, siliceous and fossiliferous bed of limestone. This is visible on the road crossing the Toll-gate ridge from Lewistown into Dry valley. Above this siliceous limestone, on the flanks of the slate ridges, layers of a purer variety of limestone are occasionally discerned, as at Mr. John Miller's, on Jack's creek. The thickness of this last mentioned belt of limestone is sometimes thirty feet.

In the lower portion of F. VIII. we often meet with a thick series of highly calcareous layers, which sometimes contain bands adapted for making *hydraulic cement*. These beds, which for convenience I have denominated the *cement layers*, are not invariably present in the formation. They are well exposed on the eastern shore of the Susquehanna river, directly opposite Selinsgrove; but between the river and Lewistown, they are scarcely discernible. The limestone previously mentioned is likewise somewhat inconstant. The title of *olive slate* given to F. VIII. in my earlier reports, is entirely applicable to the formation in the belt of country before us. Besides the greenish grey and olive colored slates which make up a large portion of the rock, occur beds of grey sandstone, and occasionally of a massive and compact blue sandstone, slightly calcareous in its composition. These are seen on the road from Lewistown to Sigler's, on Jack's creek. The strata forming the alternations of the materials of F. VIII. and F. IX. are observed as far to the south-west as a line drawn from Middleburg to Centreville. The red and grey argillaceous sandstones of F. IX., so finely exposed on the Blue Hill opposite Northumberland, extend about ten miles south-west of the river, gradually contracting to a point.

From Lewistown, south-ward, the same general valley extends for nearly forty miles, bounded on the north west by Jack's mountain, and on the south-east by Blue ridge, and beyond the termination of that, by Black Log mountain. Its average width is between four and five miles. Approaching Huntingdon county, the whole belt curves southward, conforming to the direction of Jack's mountain. Between Lewistown and the termination of Blue ridge, the general structure of the valley is that of a synclinal basin, including the strata from the bottom of F. V. to the middle of F. VIII., thrown into a number of exceedingly regular parallel lesser anticlinal and synclinal axes, the exact tracing of which becomes a matter of considerable importance from the intimate relation which subsists between them and the distribution of the iron ores of the belt.

Blue ridge terminating at Bell's furnace, its axis of elevation is prolonged seven miles further south-west, being successively overlaid by higher and higher strata, until it flattens away in F. VIII. at Orbisonia. Here the narrow synclinal axis, lying south of it, extending from Negro valley, merges into the general synclinal axis south-east of Jack's mountain; there forming one general trough between Black Log and Jack's mountains, containing the north-west and south-east dipping rocks from F. V. to F. IX. inclusive.

Commencing our description of the several formations of the belt with a brief sketch of the topography of the district, the most conspicuous ridges which we observe occupying the north-eastern end of the valley, at the Susquehanna, are the Blue Hill and the slate ridges adjacent to it on the north and south. These present a range of bold cliffs along the western side of the river. They form a belt extending from two miles above Northumberland to within a mile of Selinsgrove. These hills occupy the central portions of the valley from the river to within eight or nine miles of the Lewistown turnpike. Their outlines are highly characteristic of the formations VIII. and IX. which compose them. Their summits are usually gently rounded, their whole contour undulating, and their flanks intersected by innumerable little transverse vallies of denudation, the slopes on each side of which are of remarkably regular curvature.

The northern limit of these grey and red slaty rocks is immediately south of the limestone ridge which extends through Dry valley and Moser's valley, just south of the towns of New Berlin and Centreville, and on to David Muthbaugh's, where they terminate, a small belt of F. VIII. only continuing to the north of Dry valley. The southern limit, leaving the river about a mile north of Selinsgrove, ranges to Middleburg, bordering on the north the limestone ridge which extends past Middleburg, Beavertown, and John Sigler's. From Middleburg it continues, bordering a narrow belt between the limestone ridge and Dry valley, to the Lewistown turnpike at the toll gate.

On both sides of the hills of F. VIII. we observe the limestone ridges generally covered with fragments of the chert at the top of F. VI. and as we advance towards Lewistown, they become capped with beds of the fossiliferous sandstone or F. VII. These limestone hills have the form of continuous ridges for many miles. These are occasionally interrupted by gaps, and oftentimes entirely washed away, by denudation, for one or two miles. In Dry valley, in which New Berlin is situated, F. VI. occurs, though not in a bold and continuous ridge. Tracing this limestone, however, towards Centreville, we may often notice it assuming the magnitude of a moderately elevated narrow hill, and preserving this feature through Moser's valley. About nine miles from Centreville, a second and bolder ridge of this formation shows itself, continuing south of Mr. William Smith's, and thence near the base of Shade mountain, until it is interferred with by the axis of elevation of Little valley and Dry valley. Another ridge of the same limestone, ranging south of the slate hills of F. VIII. commences at the Susquehanna, a mile north of Selinsgrove, though other belts occur nearer the town, and runs through the valley of Middle creek, passing north of Middleburg and Beavertown, where another hill rises near it, and then passes Adamsburg, to sweep in a regular curve towards Shade mountain. Here it passes the farms of Mr. John Sigler and others, westward. From Adamsburg, westward, it is the most southern limestone ridge of the whole valley. Its outline is very regular; and its surface, cultivated nearly to the summit, presents a beautiful scollop, constituting a conspicuous and pleasing feature in the scenery. In addition to this ridge, two very singularly shaped knobs of the limestone rises between Middleburg and Beavertown, visible from nearly every part of the valley. In each of them, the rocks have a trough-like or synclinal arrangement. The summit of the southern knob is the broadest, and is under cultivation. These knobs owe their elevation to short axes or wrinkles in the strata.

Approaching Lewistown, the ridges composed of the limestone and overlying sandstone become more numerous, dividing the district into several lesser fertile vallies to be alluded to hereafter.

The hills consisting of that division of F. V. comprising the blue grey and olive coloured slates have a somewhat peculiar topography. Their outline is irregular and even ragged. They fold round the ends of Jack's mountain and Shade mountain encircling them at the base. They embrace then usually three summits, the central or broadest, containing the prolongation of the axis of the mountain. Two of these slate hills range along the northern base of Shade mountain, with rather vaguely defined summits from nearly opposite Middleburg, to about two miles east of Beavertown, becoming conspicuously marked from thence to a point three miles west from Adamsburg, leaving the mountain in consequence of a great curve which it takes while they maintain their nearly straight direction. From the above point, to Lewistown, they are less prominently defined in the scenery owing to their close proximity to the mountain. From some cause, no corresponding ridges range parallel with the southern base of Jack's mountain. Enumerating as concisely as possible the several axes of elevation which traverse the belt from the Susquehanna southwestward; the first is the anticlinal axis of Longstown ridge which brings to the surface near its summit the red and grey alternating beds of Fs. IV. and V. This axis prolonged enters Jack's mountain. South of this, the next axis observable on the Susquehanna is the great synclinal depression of the strata controlling the structure of the whole valley. It commences at the river in the Blue Hill, forming a basin in the red rocks of F. IX. and extends southwestward centrally until the uppermost rocks are the slates of F. VIII. It passes about two and a half miles north of Middleburg. Parallel with this is the anticlinal axis observed about a mile north of Selinsgrove, which has lifted the limestone F. VI. to the surface. This is probably but the prolongation of the main axis of Shade mountain marking the line along which the rocks of that ridge have undergone their greatest elevation.

Moser's valley consists chiefly of F. V. and includes two limestone ridges of F. VI. The northern of these seems to be the continuation of that which runs south of Centreville, prolonged with occasional interruptions to within a mile of Mr. John Troxell's, while the southern more elevated ridge ranges far beyond Shroyer's. An anticlinal axis has evidently lifted to the surface the underlaying stratum F. V. occupying the narrow belt between them. There is an anticlinal axis in Middle creek valley ranging near Middleburg, lifting to the surface the red shale of F. V. about a mile and a half from the town, but not bringing up the next lower division of the formation containing the *fossilferous iron ore.* West of south, a little distance, from the town it brings to view the green calcareous shales of the formation. It is thence prolonged between the northern insulated knoll of limestone and the ridge immediately north of Middleburg, disappearing between Beavertown and Adamsburg. A short anticlinal axis elevates the rocks between the pair of limestone knolls and the southern solitary knoll. The effect of the dying out of these axes is to bring the limestone ridge north of Adamsburg, nearer to the foot of the Shade mountain where it finally vanishes.

A new group of axes of elevation present themselves when we approach within ten or twelve miles of the Lewistown turnpike. The first of these ranging about half a mile from the foot of Jack's mountain brings to the surface the red shales of F. V., the second, the calcareous shales along the centre of Dry valley, lifting into view some useful belts of limestone. The third extends along a small valley north of what we have called the "Toll-gate ridge," and the fourth ranges immediately past Lewistown. The most northwestern of these, crossing the Kishicoquillas creek, above the forge of Messrs. Hall and Rawle, is prolonged for about eighteen miles, ranging through Ferguson's valley and terminating in the north-east end of Long hollow. The next towards the south-east crosses the creek about three-fourths of a mile south-east of the former and traversing the ridges which bound Ferguson's valley, passes a fourth of a mile north of Hope, and half a mile north of the Waynesburg furnace, to terminate also near the head of Long hollow. South-east of this, another axis lifting the strata, originates about two miles north-east of Hope furnace, and extends south-west for nine miles passing immediately by this and Waynesburg furnace, to disappear two miles south-west of the latter in the head of Greenbriar valley. The next in order, the third upon the turnpike, crosses Kishicoquillas creek three-fourths of a mile south east of the second, and passing a mile and a half north-west of Lewistown. Its course thence is about twenty miles, ranging three hundred yards south-east of Waynesburg, and ending two miles north of Newton Hamilton at Glasgow's mill. The fifth axis of the group, passing half a mile south-east of Lewistown, ranges south of Strode's mill, forming a ridge running thence nearly a mile south of Waynesburg and through the town of Newton Hamilton, beyond which it terminates. The sixth and last of these lines of elevation, is a continuation of the anticlinal axis of Shade mountain. From the point where this ridge subsides south-east of Lewistown, the axis which has upheaved the strata along its summit, is still prolonged, elevating other rocks for twenty-eight miles to the south-west. It passes two miles south-west of Waynesburg and a mile and a half south of Newton Hamilton, crossing the great loop of the Juniata, and ranging close south of the outlet of Aughwick creek, ending finally at Shirleysburg. Between the fifth and sixth lines of elevation, another axis originates opposite Newton Hamilton which becomes that of Prater's ridge, uplifting there the sandstones of F. VII. The inclination of the several belts of rocks uptilted along these lines of elevation is usually steep and as a consequence, the general valley consists of a number of parallel belts of formations V. VI. VII. and VIII., the softer or more readily denuded of these occupying the vallies, the harder and more resisting composing the intervening ridges.

Iron ores. Having now given a brief sketch, as minute as was compatible with the present report, of the range of the several formations in this belt. I shall proceed concisely to describe the indications of iron ore which they exhibit. The *fossiliferous iron ore* of F. V. is by far the most continuous variety, though after careful investigation we have no where discovered it either pure enough or in sufficient abundance to make it an object of economical interest. It exhibits only occasionally the square fracture characteristic of its purer bands near the outcrop. This feature it has near N. Middleswarth's mill race near Beavertown, but generally it breaks into roundish pieces and consists of much sand cemented by yellowish brown oxide of iron.

A thin seam of this ore extends along the north side of the valley following the flank of Jack's mountain beneath the red shale. It must necessarily cross Kishicoquillas creek, but the thinness of the band has prevented our finding it there, though the hard encrinitic white sandstone so usually associated with it appears well exposed and was extensively traced. The ore seam was not found in place until F. V. was followed into Moser's valley, where the outcrop was detected in a field belonging to Mr. Andrew Romick. The position of the ore in this valley appears to be immediately above the narrow belt of hard sandstone. Being of the composition above described its quality is bad. Its thickness, probably unimportant, was not ascertained. The same sandstone ridge ranges past the farm of Mr. John Featherolf, accompanied by the ore of too impure a quality, however, to be valuable. Its course eastward ought to be along the base of Longstown ridge, but our efforts to trace it were unavailing, while from observations made during both the past season, and the previous one, in Union county we are led to conclude that it is invariably too thin and impure to be productive. The ore again rises to the surface occupying its usual place in the formation along the south side of the valley adjacent to the base of Shade mountain. We detect it in its true position in a beautiful section of the strata at Mr. Ner Middleswarth's mill. The excavation in the mill race shows the encrinitic sandstone supporting the fossiliferous ore in the form of a very hard and siliceous sand from four to six inches thick. Above the ore rests a mass of greenish shale about one hundred feet thick and over this a somewhat variable shale of a cherry red colour sustaining in turn a series of calcareous shales occupying the place of the limestone bands of the formation and supporting the well known brownish red shales at the top of the series. No difficulty existed in tracing the ore along the base of the slate hills south of Adamsburg and Beavertown, and it was also followed along the foot of the slate hills south of Middleburg, but it is rarely of sufficient purity, and in no place thick enough to make it practically useful. Near Lewistown, especially seven miles to the west, it has been opened in many places, and its thickness though increasing in that direction is even there not considerable.

Another distinct band of ore occurs sometimes in F. V. among the buff and olive shales already described. It is of a light brownish colour, and is generally too small in amount and too impure, to be valuable.

The limestone ridges of F. VI. frequently exhibit considerable quantities of iron ore upon the surface; yet, from the shallow depth of the earth above the rock, and from other indications, we deem the prospect a slender one of finding a useful deposite in this formation as it occurs in Union and Mifflin counties. This superficial display of ore is visible on the ridge north of Adamsburg, and also on one of the isolated knobs near Beavertown.

No useful quantity of ore would seem to occur in either F. VII. or F. VIII. north-east of the Lewistown turnpike. The first of these formations dwindles in thickness as it approaches the Susquehanna, and also is much less ferruginous than in Huntingdon and Bedford counties.

F. V. South-east of Lewistown.

Lewistown is situated on the border of F. V. and F. VI. or of the shales and limestone, F. V. occupying the entire space from the town to the base of the mountain south-east of it, called Blue Ridge.

This belt is at least one mile and a half wide, and continues of this breadth as far as Waynesburg. At Lewistown, the stratum have been lifted to the surface by two anticlinal axes, while opposite Waynesburg it is thrown up in three lines of elevation. The first of these, south of Lewistown, begins to form a ridge east of Strode's mill, which continues for six miles, ending south of Waynesburg. This ridge is composed of the fossiliferous sandstone belt of F. V. and has the fossiliferous iron ore resting on both of its flanks. South-east of Waynesburg, the limestone F. VI. lies in the synclinal axis. South of the anticlinal axis, and three miles south-west of the same town, F. V. with the fifth anticlinal axis in it, is overlaid by the limestone.

The anticlinal axis of Shade mountain, in elevating F. V. brings the fossiliferous iron ore to the surface, in a double line of outcrop, for a mile and a half south-west of the end of the mountain, beyond which the ore sinks below the surface—the axis exposes the higher parts of F. V. for about fifteen miles, when the red shales disappearing altogether, it is prolonged in the limestone beds of F. VI., entering this formation opposite Galloway's Gap, in Blue Ridge. The limestone forms a trough between this axis and the mountain, commencing between four and five miles east of this point and extending to the bend of the Juniata, a narrow ridge of the overlying sandstone of F. VII. rising near Galloway's Gap, and running along the centre of the basin to the river.

The belt which ranges along the base of Blue Ridge being separated from the other belt elevated by the Shade mountain axis by this tract of limestone, ranges towards the south-west, passing Bell's mill, and finally folds round the end of Blue Ridge, to enter the synclinal basin of Negro valley. The rocks of this formation, resting at the foot of the mountain, extend about one-third of the way up its aclivity, and spread into the valley a few hundred yards from its base, dipping to the north-west, at an angle of about fifty degrees. Where it saddles the axis of Blue Ridge, it lengthens itself to the south-west so as to form a considerable portion of Germany valley, the hard sandstone stratum forming a curious semicircular ridge sweeping round the end of the mountain. In Negro valley, this formation lies in a trough, or, in other words, its strata dip from both sides towards a central line or synclinal axis, being elevated on the north-west by the anticlinal axis of Blue Ridge, and on the south-east by that which has uplifted the Black Log mountain. Nearly opposite the end of Blue Ridge, the upper strata of F. V. are overlaid in the middle of the basin by the next succeeding formation, the limestone. The north-west dipping beds of F. V., resting at the base of Black Log Mountain, form a belt which ranges with great regularity along its flank for eighteen miles, to Fort Littleton. The mountain then terminating, the zone of red shale is joined by another which follows the south-east flank of Shade mountain, and the two fold together at Littleton over the anticlinal axis prolonged from Black Log valley, forming a tract of good soil, occupied by several farms.

FORMATION V.—*North-west of Lewistown.*

The formation at Brown's gap, where Kishicoquillas creek passes through a deep notch in Jack's mountain, is about a mile and three-quarter's wide, forming the north-west side of Ferguson's valley, and extending half way up the slope of the mountain. This belt of F. V. is traversed by the first anticlinal axis of our enumeration, which lifts to the surface the *fossiliferous* ore about two miles south-west of the gap. The existence of the ore is indicated by a ridge extending along the north-west side of Ferguson's valley, and which consists of the grey sandstone stratum of F. V., immediately supporting the ore. The anticlinal axis running along the centre of this little ridge of sandstone, the fossiliferous ore is brought up in a double line of outcrop, one portion resting on each flank. The ridge extends south-west between five and six miles, where the gentle subsidence of the strata over the axis causes the ore to disappear below the surface; and two miles further south-west, the whole of F. V. itself, along the line of the axis, also passes out of view, being overlaid by the limestone. For some distance previous to the disappearance of the red shales along this axis, the limestone occupies a narrow trough between this range of the formation and the other which rests against the foot of the mountain. This latter belt of F. V. its beds dipping about thirty degrees towards the south-east, continues along the slope and base of Jack's mountain for about nine miles, when it begins to recede from its flank so as to rest only at the mountain's base when we reach Drake's ferry. This portion of it, therefore, forms the north west part of the valley called Long Hollow, the strata here dipping twenty-two degrees to the south-east.

Traced south-westward from the Juniata, F. V. occupies the north-west side of Dry valley—a valley lying between Jack's mountain and Chesnut ridge. Here its beds dip thirty-five degrees to the south-east. It preserves this position at the base of the mountain, which it follows to its termination, about fifteen miles, folding round its south-western end, at the Three Springs, to meet a parallel belt occupy the other base of the mountain in Hare's valley. Where the formation climbs some distance up the flank of the mountain, the hard grey sandstone forms a slight but distinct ledge along its slope; but where it rests only at the base, this band constitutes a sharp-crested ridge, ranging through the south west end of Long Hollow, and traversing the north-west side of Dry valley for a considerable distance.

Fossiliferous iron ore of F. V.

With a single exception, all the furnaces situated in the belt of country before us from Lewistown to Maryland, being nine in number are supplied with two varieties of iron ore. One of these is the fossiliferous ore for the formation above described. The other belongs to the lower layers of F. VIII. to be hereafter noticed. Their distribution being entirely dependant on minute features in the geological structure of the valley connected with the axes of elevation, the work of tracing then becomes a matter of systematic research, making a correct knowledge of the position of the strata and their axes, of indispensible importance.

Confining ourselves for the present to the fossiliferous ore of F. V. I deem it useful again to allude to its close association with the grey fossiliferous sandstone which forming often a prominent feature on the surface proves so valuable an index to its position. Generally throughout the belt of country before us, the uppermost layer of this sandstone is a hard bed varying from fifteen to thirty feet in thickness, consisting sometimes of a fine grained white or yellowish brown rock, filled with numerous cavities of *encrini* and other fossils.

The fossiliferous ore besides cropping out in a narrow line following the flank of each of the mountains bounding the general valley, is lifted to the surface for a certain distance along two of the anticlinal axes which traverse the district between Lewistown and the Juniata at Drake's narrows. The belt of ore on the flank of Jack's mountain has not been opened north-east of Drake's Gap. Here however, it has been smelted in Matilda Furnace, making a good iron. At this place the whole thickness of the seam of ore is about sixteen inches; the upper half, only, however, being pure enough for the furnace. This, averaging about eight inches in thickness, is very similar in aspect and composition to the ore of acknowledged excellence in other parts of the same deposite, being hardly distinguishable from that of Montour's Ridge, or that of Woodcock valley at the base of Tussey's mountain. It is rather less rich in iron though in other respects quite as good. This belt of eight inches is separated by a band of three or four inches of tough greenish slate from a lower layer of nearly equal thickness, containing only about half the proportion of iron in the former and consisting largely of sand and other extraneous matters. Though possessing somewhat the aspect of the true fossiliferous ore above it, it is too siliceous and too poor in metal to make it useful, even for mixing with the richer ore. The two analysis given in chapter VI. will show the composition of each of these divisions of the ore bed at Matilda furnace.

The same bed of ore presenting very nearly the same features occurs in Dry valley, south-west of the Juniata. One of the belts thrown up by the anticlinal axis of the north-west side of Ferguson's valley, has been opened at several points for the supply of Hope furnace. It is the southern dipping band, the northward dipping ore being very steep which as a general rule somewhat lessens the value of the stratum.

The ore brought up to the surface by the fifth anticlinal axis of the valley extends from a point south-east of Strode's mill, to a point south-east of Waynesburg, accompanying the usual ridge of sandstone. The bed in this range is not more than four or five inches thick, but resting upon the upper layers of the hard sandstone and overlaid by a very shallow covering of soft shale it is readily accessible. In some places it nearly saddles the axis of the ridge near the north-east extremity, of which several excavations have been made; the ore is used at Hope furnace.

The band of ore extending along the north-west flank of Blue Ridge has not been opened between Lewistown and Bell's mill. Near the latter place the Juniata cuting the belt of sandstone at the bluff called Blue Rock, exposes the ore which exists here in two thin layers not of sufficient magnitude to be valuable. At Bell's furnace the same layers as they sweep round the termination of Blue Ridge have been worked, though their insufficient thickness has caused them to be abandoned.

F. V. in Pigeon Cove.

Pigeon Cove, commencing in the southern part of Bedford county, and extending into Maryland, is a small valley of elevation consisting of F. V. bounded on all sides by a rim of hills composed at their base of the limestone F. VI. Its length in Pennsylvania from the State line to the head of the valley is between six and seven miles, and its width at the Maryland line is about a mile and a half. The axis of elevation which has upheaved the shales of F. V. along the middle of this valley and caused the adjoining strata to dip away in opposite directions, is apparently a prolongation of the great axis of Black Log valley, which there brings to the surface a much deeper seated set of rocks. Had the uplifting action been only a little more powerful, or the denudation deeper in Pigeon Cove, there can be no doubt that a valuable band of the fossiliferous ore would have been exposed, inasmuch as further to the south in Virginia, where such a state of things prevails the bed reaches the surface in two parallel lines of outcrop. As it is, only the superior portion of the formation lying above the ore is exposed.

F. V. at the base of Scrub Ridge.

The red and variegated shales or F. V. probably exist in a perpendicular attitude at the base of Scrub Ridge, extending from the Burnt Cabins for six or seven miles towards the south-west, where they are lost below the surface in consequence of an enormous dislocation of the strata which extends along the north-west side of the McConnellsburg Cove. They emerge again south-west of Hunter's mill, and thence extend along the flank of Dickey's mountain, to its termination, folding round to meet another belt of the same formation, which occupies the north-west side of the Little Cove.

F. V. in Little Cove.

A wide border of F. V. encircles the valley called Little Cove. Commencing high up on the slopes of the Cove mountain, just where the Chambersburg turnpike ascends it, north of Louden, the formation ranges along the trough or synclinal axis of the valley in a S. S. W. direction between nine and ten miles, where the deepening of the basin permits the red shales to be overlaid along the south-eastern side, by a belt of limestone, F. VI. which divides it into two zones. That on the north-west is broad, its strata having a rather gentle inclination to the south-east, about thirty degrees, the formation spreading over a considerable portion of the north-west side of the cove. Towards the south-west this gradually contracts and finally unites as before mentioned with the belt which sweeps round the end of Dickey's mountain near the State line. The other or south-eastern zone is narrow and extends high up on the flank of the Little Cove mountain, its strata being nearly perpendicular.

Formation V. as it appears in Little Cove, includes two important beds of sandstone, each nearly one hundred feet thick, separated by about the same thickness of olive and yellowish beds of shale. The lower of these is a red sandstone, the upper, a white sandstone, and the position of the *fossiliferous iron ore*, is in the shales which lie between them. These belts of sandstone constitute the ridge along which the turnpike ascends from a mile north of Louden to the toll gate on Cove mountain. Along the north side of Little Cove, they likewise range in a high ridge, upon the east of which the *fossiliferous ore* was traced for eight or nine miles south-west, from the Mercersburg turnpike. On the south-east side of the Cove, these sandstones do not give rise to a separate ridge but rest high up in the slope of the bounding mountain.

The fossiliferous ore thus discovered cropping out along the north-west side of the synclinal axis of Little Cove, was traced by the fragments scattered on the surface for nearly fifteen miles.

FORMATION VI.—*Fossiliferous Limestone.*

F. VI. from Lewistown to Fort Littleton. Between the first and second anticlinal axes north-west of Lewistown, occurs a synclinal axis in the *fossiliferous limestone* F. VI. which forms a high ridge on the Bellfonte turnpike. The second or northern anticlinal axis, lies also in the limestone. But about a mile towards the south-west the sandstone F. VII. begins to occupy the line of the synclinal axis separating the limestone into two belts. That on the north-west, bordering the south side of Ferguson's valley, and continuing for nine or ten miles, ranges at the base of the sandstone ridges, until nearly opposite Waynesburg, where it folds into the limestone of the basin north of it, saddling the northern anticlinal axis coming out of Ferguson's valley. This belt is thence prolonged to the south-west about two miles further where a ridge of sandstone begins to overlie the northern side of it, subdividing it for about four miles, into two narrow tracts and then ceasing in order to allow these to reunite at the north-east end of Long Hollow.

The second anticlinal axis counting southward from the mountain, elevates to the surface a narrow belt of the limestone varying from two to six hundred yards in width, and extending from a point north of Lewistown to Atkinson's mill, a distance of eighteen miles. For a portion of this distance it forms the crest of a ridge flanked on each side by the sandstone beds F. VII. About a quarter of a mile north-west of Waynesburg furnace, this ridge has been cut down by denudation into a little valley about two miles in length. At Atkinson's mill in the east end of Long Hollow the narrow ridge of sandstone lying between this limestone and another belt of the same rock on the north ceasing, the two merge together into a broad tract, nearly a mile in width, having two anticlinal axes near its eastern end which die out two or three miles to the south-west in Long Hollow. The limestone extends along the south-east side of this valley dipping only in one direction, or towards the south-east. Where the belt reaches the Juniata, it is half a mile wide. Traced still further towards the south-west, it forms the south-east side of Dry Valley, and reposes at the base of Chesnut Ridge under the sandstone F. VII. Preserving a gentle dip it advances about fifteen miles beyond the Juniata, to the Three Springs where it folds over the red shales which saddle the axis of Jack's mountain and meets the belt that in a similar manner traverses Hare's valley.

The third anticlinal axis counting from the mountain, which does not appear on the Bellefonte turnpike brings into view a narrow belt of the limestone, commencing about two miles north-east of Hope furnace. In its course towards the south-west it passes under this furnace and also under the Waynesburg furnace, ending a mile and a half south-west of the latter. It is overlaid on each side and at both ends by the sandstone F. VII. constituting the crest of a ridge a few hundred yards in breadth while the sandstone forms the flank.

The fourth anticlinal axis developes the limestone a little north of the toll gate near Lewistown. This rock then constitutes the crest of a ridge flanked on both sides by the sandstone. Its width is between three and four hundred yards. About five miles south-west o Lewistown, it merges into the next adjacent belt of limestone which passes immediately by Lewistown. The synclinal axis or trough between the ranges is occupied by the sandstone capped by the slates of F. VIII, which there cease. The limestone beyond this point consisting of but one narrow belt, ranges north of Strode's mill and south of the sandstone ridges passing the town of Waynesburg, a mile beyond which it again widens and finally divides into two projecting points or tongues by the commencement of a broad ridge of sandstone lying in the synclinal trough between the fourth and fifth anticlinal axis. The north western range runs for a mile and a half and then disappears beneath the overlying sandstone about four miles south west of Waynesburg. The south-eastern portion ranges about four miles further, following the fifth anticlinal axis along which it joins another belt of the same limestone which commences south of the Juniata about two and a half miles east of Waynesburg. The broad belt formed by the union of these two, is a second time subdivided by a ridge of sandstone, at a point near the canal about five miles below Newton Hamilton, the northern prong running to a point between sandstone ridges about a mile and a half to the west, while the southern division extends in a regular belt to the great bend of the Juniata. This latter range when opposite to Galloway's Gap, is joined by another occupying a narrow trough at the foot of the mountain which commences about three miles south of Waynesburg, and half a mile south-east of the river. This last and most south-eastern belt containing a synclinal axis embraces along its centre a narrow ridge of the overlying sandstone commencing opposite Galloway's Gap and running to the bend of the Juniata, dividing the limestone into two vallies. That next the mountain called Sugar Valley, is the narrowest. The limestone ranging along the north-west side of this ridge and between it and another sandstone belt following the Juniata, gradually contracts in width towards the bend of the river, which it crosses one mile south of Newton Hamilton passing the mouth of Aughwick creek and becoming the crest of Owen's ridge. It ceases altogether about a mile north-east of Shirleysburg, where it is overlaid by the sandstone F. VII.

Prater's ridge, consisting of the limestone and overlying sandstone, owes its elevation to an anticlinal axis, developed in the latter. It commences south-east of Newton Hamilton, and extends for about three miles, running close to the north-west base of Owen's ridge, forming a narrow trough or synclinal valley of F. VIII. between them.

The subdivision of the limestone which traverses Sugar Valley, crosses the bend of the Juniata north-west of Bell's mill, beyond which it borders the north-west side of Germany valley, at the south-east base of Owen's ridge. At the western extremity of Germany valley, three miles from the end of Blue ridge, the zone of limestone closes over the anticlinal axis prolonged from the mountain, and sweeps round towards the east and forms a basin at the mouth of Negro valley. Thus augmented in breadth, in curving round the head of Germany valley, it becomes soon subdivided, by receiving in the middle of the basin, south of the end of that valley, a sandstone ridge of F. VII. separating it into two distinct belts towards the south-west. The most northern of these ranges three miles from the commencement of the ridge, and finally disappears, one mile north-east of Orbisonia, in the anticlinal axis, where it is saddled by the sandstone. The other, or south-east division, ranges towards the south-west, with great regularity, for fourteen miles, following the base of Black Log mountain. It passes north of Winchester furnace and south-east of Madden's mill; and about a mile south-west of Littleton, it meets the belt which pursues the south-east base of Shade mountain.

F. VI. at the Foot of Scrub Ridge.

At the Burnt Cabins, near the line of Bedford county, the limestone is seen in a perpendicular position, extending along the north-west side of the prolongation of the anticlinal axis of the cove. It probably continues south-west for six or seven miles in that altitude, until lost in the great dislocation, before referred to, at the base of Scrub Ridge. It emerges again on the north-west flank of Lowrey's knob, and passes thence a short distance south-east of Hanover furnace, and along the base of Dickey's mountain, where it passes into Maryland, and finally folds round the end of that ridge, saddling its anticlinal axis, and uniting with the north-western belt of the formation in Little Cove.

F. VI. in Little Cove.

The limestone begins to show itself along the south-east side of the Little cove, south-west of the Mercersburg turnpike, and extends down the cove for several miles, when the overlying sandstone commencing, it divides, one belt crossing the cove westwardly to follow its north-western side, the other belt preserving a steeper dip, running along the south-east side of the base of the Little Cove mountain. The first range passes three-fourths of a mile north-west of Warren furnace, and crosses the State line at the base of a ridge capped by the sandstone.

Pigeon Cove is belted on both sides by this limestone, having its usual fossiliferous character. It forms the base of the enclosing hills, called the Conolloway ridges.

Iron Ore.

This limestone formation has been carefully examined throughout the several belts here described, with a view, if possible, to discover workable deposites of iron ore. In many places, indeed, it exhibits in the soil scattered lumps of a compact chesnut brown ore, of excellent quality; but the shallowness of the earth resting over this rock, and other causes, seem to have prevented the accumulation of large deposites, such as we find in the great belts of limestone belonging to F. II. Somewhat extensive accumulations of ore do occur in the ridges at the base of which this limestone usually lies; but these are subordinate rather to the sandstone F. VII., which caps those ridges, than to the underlying limestone. They will be mentioned, therefore, in the next section.

FORMATION VII.—*Fossiliferous Sandstone.*

Formation VII. from Lewistown to Maryland. In the belt of country at present before us, this sandstone is of no great thickness, varying from fifty to one hundred feet. Its lower beds consist of an argillaceous buff coloured sandstone, in which the siliceous particles, though abundant, are often of extreme minuteness. Its colour is yellowish or buff, and it breaks into rectangular fragments. Its upper portion, on the contrary is a coarse grained sandstone, usually white or brownish. Wherever this formation appears, it almost invariably constitutes a sandy and rugged ridge. The most north-western ridge of this formation, lying near the foot of Jack's mountain, commences two miles north-west of Waynesburg, and terminates one mile north of Atkinson's mill. The next begins about a mile south-west of the Bellefonte turnpike, and ranges for seventeen miles, including, probably, in its trough, a narrow belt of F. VIII. for most of this distance. It bounds Ferguson's valley on the south-east, passes north-west of Hope furnace, thence by Huling's saw-mill, and ends north of Atkinson's mill, near one of Mr. Patton's ore banks. The third belt commences about a mile north-west of Lewistown, and separates into two ridges, about two miles north east of Hope furnace. That on the north-west, embracing a narrow strip of the slates of F. VIII., passes north-west of the furnace and a few hundred yards north-west of Waynesburg furnace—two miles beyond which it widens out, admitting a wider belt of the slate upon it, which soon divides it into two ridges, the south-eastern ending near the head of Green Briar valley, and the other continuing to the south-west, bordering that valley and Long Hollow to the Juniata. Arriving at the river, this belt crosses and becomes Chesnut ridge, bounding Dry valley on the south-east. It continues thus for fifteen miles to the Three Springs, where it forms a semicircular ridge, sweeping round beyond the end of Jack's mountain to meet another belt, forming Rocky ridge, in Hare's valley.

The south-eastern division of this ridge, with which we started at the turnpike north of Lewistown, passes two hundred yards south-east of Hope furnace and several hundred north of the town of Waynesburg, to the south-west of which it divides, sending one portion to unite with the ridge which ends at the head of Green Briar valley, and the other further to the south-west, to form the general south-eastern boundary of Green Briar valley, and to form a part of the broad table land of sandstone which occupies most of the space between this valley and the Juniata, and which ends near Newton Hamilton.

Another sandstone ridge, the most south-eastern of the series, seen immediately north-west of Lewistown, extends for several miles along the Huntingdon turnpike until it terminates about half a mile north of Strodes' mill. This belt of sandstone, like most others, supports a narrow strip of F. VIII. along its summit, protected from denudation by occupying the middle of a trough in the strata.

The broad table land of sandstone already mentioned, sends a narrow ridge or tongue, ending a little west of Newton Hamilton. It also, in consequence of a short anticlinal axis, protrudes another similar promontory across the Juniata, at the dam below that town; while the ridge forming its south-eastern margin, crossing the river a third of a mile below the dam, recrosses it twice more at the bend, and passes it just at the mouth of Aughwick creek, and thence runs to Shirleysburg, flanking Owen's ridge on the north-west.

The short anticlinal axis of Prater's ridge brings up the sandstone south of Newton Hamilton. This belt of the formation crosses the bend of the Juniata, and forms, with the belt just described, a narrow trough, extending between two and three miles south-west, and embracing a little belt of the slates of F. VIII., forming a valley for Aughwick creek.

The south-eastermost belt of sandstone is the ridge bounding Sugar Valley. Commencing opposite Galloway's Gap, it soon includes, like the rest, a narrow zone of the the dark slates of F. VIII. lying along the trough in its summit. This zone of F. VIII., becoming thicker towards the south-west, embraces, about three miles from its origin, a highly important band of *iron ore*, opened at Mevey's ore bank. The ridge, and its contained belt of slate, crossing the Juniata north of Bell's mill, presents us with another exposure of the ore at Bell's ore bank. The band of ore follows the slate for some distance towards the south-west, lying now nearly on the crest of Owen's ridge. The belt of slate widening and deepening towards Shirleysburg, the sandstone ridge separates—one part folding over the axis of Owen's ridge to meet the corresponding sandstone beds of its north-western flank, terminates near Shirleysburg; the other running on to the south-west, ends near Orbisonia, by saddling, in like manner, the axis prolonged from Germany valley, and uniting with another belt of sandstone, forming part of Sandy ridge, on the south-east. This last named ridge crosses Black Log creek above Winchester furnace, and continues thence parallel to Black Log mountain, with a uniform north-west dip, for several miles. Near the south-west end of Black Log mountain, it gradually leaves its base—Aughwick creek flowing in the limestone valley between them. The sandstone ridge north-west of Littleton is a continuation of this belt of F. VII., which meets a corresponding belt that ranges along the south-east side of Shade mountain, at a point about a mile and a half south-west of Littleton, where the two-fold together, saddling the anticlinal axis of Black Log valley.

The sandstone F. VII. as developed at the base of *Scrub Rridge*, consists only of a few layers of fine conglomerate and some massive beds of calcareous sandstone, containing the common fossils of the formation. It is in all probability not more than twenty feet thick. It loses itself a few miles north of McConnelsburg, near the commencement of the great dislocation at the foot of Scrub Ridge, and does not emerge again towards the south-west for several miles.

When it does appear it follows closely the range of the underlying limestone before described.

In *Little Cove*, the formation consists of beds of fine conglomerate and of coarse sandstone much impregnated with iron. Between five and six miles south-west of the Mercersburg turnpike, and three miles south-east of Warren Iron works, the sandstone commences in the synclinal axis of the Little Cove. It soon separates into two belts, that on the north-west, forming a considerable ridge running near the side of the Cove, and about three fourths of a mile north-west of the Warren works. The other division ranges along the south-east side of the Cove, forming also a distinct ridge, which passes about the same distance south-east of these works.

The ridges bounding *Pigeon Cove*, are capped by this formation developed in considerable thickness. The rock consists of a fine grained conglomerate and a coarse brownish-yellow sandstone, having the usual appearance and the characteristic fossils of F. VII.

Iron Ores of F. VII.

Near Chester Furnace in Huntingdon county, there is a valuable deposit of cellular brown iron ore in the belt of F. VII., which composes Chesnut Ridge. The sandstone here consists of two members, the upper a soft coarse grained sandstone, the lower a buff coloured, fine grained and very argillaceous sandstone, remarkable for its square cleavage. Precisely at the junction of these two strata, occurs the ore in a bed usually about two feet thick. It is generally more or less sandy and what is even more detrimental, contains frequently a large amount of *oxide of manganese*. It seems to be derived from the filtration through the upper porous and ferruginous sandstone carrying down the oxide of iron to the top of the less penetrable argillaceous bed beneath. This ore has been dug at several places, but the efforts hitherto made to smelt it have proved unavailing in consequence of its extreme impurity.

Formation VIII. Dark Olive Slates.

In the belt of country before us, the lower layers of F. VII. consist for the first thirty feet or thereabouts of a very dark slate. Above these occur the calcareous beds called by us the *cement layers*, from containing occasionally a good *hydraulic cement*. These are generally but a few yards thick. Over them, varying a little as to their precise position, are bands of an impure *carbonate of iron*, which when unaffected by the action of the atmosphere is of a bluish-grey or lead color. These support a thick mass of black slate upon which repose in turn the grey sandstone and olive slate, distinctive of the middle divisions of the formation. Higher in the series are buff, olive, and sometimes pinkish slates, generally very soft and friable.

In the greater number of the synclinal ridges of the sandstone, a narrow trough running centrally along the summit, contains only the black slate at the very base of F. VIII.

In the ridges of a different structure this black slate occupies a narrow valley with the coarse sandstone of F. VII. on one side, and hills of the grey sandstone, and olive slate on the other. The hills of the upper part of the formation are more rounded. These features in the topography are thus specified, as affording an important clue to the range of the iron ore above described, which seems to be a continuous bed, following the calcareous layers of the lower part of the formation, sometimes for a mile. From the general steepness of the dip in the several belts of the sandstone F. VII. and from its trivial thickness, these valuable lower layers of the overlying stratum F. VIII. have been effectually protected from denundation along the troughs or synclinal axes, affording a beautiful provision for the protection and distribution of the iron ore.

In tracing the narrow ridges of the sandstone, I took occasion to mention these included belts of the lower layers of the overlying slate: it is needless therefore to describe again their range. I shall therefore, mention only those belts in which the important ore accompanying them is worked.

The ore bank one mile north of Atkinson's mill, wrought by Mr. Patton, for the supply of Hope furnace, is situated in this formation. The belt here is that of the second sandstone ridge, south of Jack's mountain, lying between the first and second mentioned axes.

The ore dug a little west of Waynesburg furnace, occurs in the belt between the second and third anticlinal axes.

The ore diggings of Chester furnace, belong to the lower layers of F. VIII., cropping out on the north-west side of the wide basin of great Aughwick valley, a continuation of that of Green Briar valley.

Mevey's and Bell's ore banks already mentioned, occur in the synclinal axis between the sixth anticlinal axis and Blue Ridge, in the corresponding belt of F. VIII. on the summit of the sandstone ridge.

Morrison's ore bank is on the outcrop of the same lower layers of the slate on the south-east side of the synclinal axis, between Prater's Ridge and Chesnut Ridge.

The ore banks of F. VIII., near Orbisonia, are in the same synclinal axis, which is continued from the middle of Negro valley.

The precise geological situation of this valuable and most extensive band of ore is here given, in the hope that individuals interested in the subject, may by attending carefully to our descriptions of the formations in their several complicated belts, and by taking as a guide the various anticlinal axes or lines of elevation, and synclinal axes, or lines of depression, trace for themselves the course which it takes along the hills. The discovery in the prosecution of our researches of the continuous nature of this ore in the lower layers of F. VIII., and of the no less valuable bed of fossiliferous ore peculiar to F. V. furnishes just cause of satisfaction to those engaged in the geological survey.

Green Briar Valley.

Formation VIII, with gently dipping strata, commences at the north-east end of this basin, two miles from Waynesburg, where two narrow belts which previously occupy the summit of the third and fourth sandstone ridges, counting from Jack's mountain, coalesce by the dying out of the anticlinal axis of the limestone valley of Waynesburg furnace. This valley is widest opposite Glasgow's mill, on Beaver run, being there about a mile and a half from south-east to north-west.

South-west of Newton Hamilton, where the fifth anticlinal axis with its ridge of sandstone ends, it merges into another broad belt of F. VIII. lying north of Prater's Ridge, the united tracts of the olive slate being here two miles in breadth. Prater's Ridge uplifted by an anticlinal axis separates this broad belt for a space into two, forming a narrow one between it and Owen's Ridge, and leaving the principal portion of the formation on its north-west, spreading across the whole of the great Aughwick valley to the base of Chesnut Ridge. The belt then continues to the south-west, bounded by Chesnut Ridge and Owen's Ridge, the latter ending at Shirleysburg. Here the main basin of F. VIII. is about two miles wide. Beyond the end of Owen's ridge, its boundary on the south-east, is the ridge of sandstone which terminates at Orbisonia. At Shirleysburg, the main belt is joined by a narrow one, the same which contains Mevey's and Bell's ore banks, coming from the Juniata and opening here into the general basin. In like manner another narrow tongue of F. VIII. commencing on the summit of Sandy Ridge, a short distance from its north-east extremity near Germany valley, expands by a division of this ridge and merges itself into the general body of the formation at Orbisonia, beyond which to the south-west, the main basin of F. VIII. containing but one central synclinal axis, is bounded on the south-east, by the sandstone ridge which follows the foot of Black Log mountain, and on the north-west, by that which ranges near the base of Jack's mountain. In this part of its course it is two and a half miles wide, its surface diversified with rounded swelling hills of the slate.

About three miles west of Orbisonia, and a little beyond the junction of Three Spring creek and Aughwick creek, an extensive belt of the thick overlying stratum F. IX., commences in a ridge occupying the synclinal axis in the centre of the basin. This tract of red argillaceous sandstone divides the olive slate formation into two ranges, that on the north-west running on and meeting the slate belt which traverses Hare's valley, these saddling at their junction the anticlinal axis prolonged from Jack's mountain. Where this occurs, the belt is three miles in width, being bounded on the north-west by Clear ridge. Rapidly contracting, it forms a triangular area terminating in a point eight miles south-west of Jack's mountain, when it is overlaid by the red rocks of F. IX.

The other zone of olive slate lying between the sandstone ridge at the base of Black Log mountain and the margin of the red sandstone on the north-west, runs towards the south-west, between ten and eleven miles, meeting a belt of the same formation sweeping round from the south-east side of Black Log valley, at the base of Shade mountain, at a point two miles south-west from Fort Littleton. Opposite Littleton, the belt forms a basin of simple synclinal structure, lying between the anticlinal axis of Black Log valley, and the M'Connelsburg Cove. On the north-west side the strata have a gentle dip to the south-east, but adjacent to Scrub ridge, they are perpendicular, being affected by the dislocation.

About three miles south-west of Littleton, another tract of F. IX., commences, dividing this part of the olive slates into two ranges, one stretching along the base of Scrub ridge, and the other uniting with the belt north-west of Littleton, by saddling the axis of Black Log mountain three miles from its termination. The wide belt thus composed sweeps westward to occupy the centre of the valley between Sideling Hill and Big Scrub ridge, continuing as one belt two and a half miles in width, for sixteen miles, to the north-east extremity of Pigeon Cove. Here the lower formations being protruded, it separates, one division running north-west of the Cove, the other south-east, until they both reach the Potomac.

The *Scrub Ridge* belt is *overtilted* or *inverted*, the strata dipping eighty degrees to the south-east. A considerable portion of the formation is buried under the dislocation. Opposite to M'Connelsburg, it is four hundred yards in breadth. Further west where Scrub ridge itself ceases, the hills of this formation bound the Cove. It emerges to the surface again near Hunter's mill, and at Hanover furnace, the entire formation is once more developed though its beds are still perpendicular. In this attitude it crosses into Maryland.

Little Cove, contains in the middle of its basin a broad belt of F. VIII., having a width of a mile and a half where it is intersected by the State line. Gradually contracting towards the north-east, it terminates in a point a little more than three miles north-east of Warren Iron works. The strata on the north-west side of the synclinal axis dip gently towards the south-east, while those on the south-east side are perpendicular. Warren Iron works are situated near the centre of the belt.

Iron Ore in F. VIII.

The discovery of the true nature and exact position of the iron ore connected with this formation, furnishes an interesting illustration of the utility of geological researches systematically prosecuted. The ore having been previously dug at the out crop, only at remote and scattered points, no general clue to its position applicable in practice had been detected, nor was it probable that any could be, until the order of superposition had been minutely and methodically studied. No sooner was this done however, than we perceived that all the outcrops of the ore accidently discovered in the formation, belonged to one solid and extensive band regularly interstratified in the lower part of these slates; accompanied by such well marked features in the adjoining rocks as to render the tracing of its course with proper skill and knowledge, a matter of ease and certainty. From the descriptions above given of the several belts of F. VIII. in the long and wide valley of Lewistown, some idea can be had of the truly prodigious body of this ore which remains yet undeveloped. I cannot hope however, to convey to persons not thoroughly familiar with the intricate topography of the region, a correct conception of the range and distribution of that part of F. VIII, in which this ore should be sought until I am enabled to elucidate my descriptions by the requisite maps and sections.

The stratum of ore varies in thickness from three or four feet, to ten or fifteen feet, and lies usually closely contiguous to the calcareous or cement layers of the formation, overlying them only a few feet and being removed from the upper surface of the fossiliferous sandstone F. VII. by from fifty to one hundred feet of strata. Whether it is evenly spread as one continuous deposite from Lewistown to Maryland, or whether it is less constant, thinning away and re-appearing, cannot be determined until its several belts are more explored by those interested in using it. The stratum remote from its outcrop, consists of bands of ponderous bluish grey or lead colored *proto carbonate of iron* sometimes breaking into square masses, and sometimes of a more slaty or laminated structure. It does not effervesce when touched with acid; when roasted it becomes reddish brown and is then strongly attracted by the magnet. The analysis in chapter VI. wlll display the usual composition of the ore.

It is only where the stratum has been long exposed at its outcrop to atmospheric influence, converting it into the brown *per-oxide of iron*, by which it assumes a wholly different aspect, that it forms the deposite at present worked by the furnaces situated near it. This ore, at its outcrop, is of a dark hazel brown color, a smooth grain, and a cellular structure. That which is derived from the rectangularly cleaving portion of the solid bed, is in square masses, with large squarish cells, often glazed and irridescent on their inner surface, and either entirely empty or partially filled with a pure bluish clay. Sometimes where the bed has been so protected as to escape extensive atmospheric action, this convertion to the brown *per-oxide* is only partial, a solid nucleus of the bluish *proto-carbonate* forming the interior of the lump, while the *per-oxide* occurs only on the surface, in the form of a crust of greater or less thickness. Between this crust and the undecomposed nucleus, the earthy particles, originally in that portion of the *proto-carbonate* which has been converted into the *per-oxide*, having been left by the iron in assuming its new state of concretion, lie loose in the intervening space, forming a dust when dry, and when moist a tenacious clay. This travelling of the atoms of *oxide of iron* from the interior to the circumference of the mass, in all cases where a *proto-carbonate of iron* undergoes conversion to the *per-oxide*, is a highly curious fact which science has not yet explained.

Distribution of the Ore.

It is probable that this bed of ore extends, either partially or uninterruptedly, for considerable distances in nearly all the synclinal axes where the lower beds of F. VIII. occupy the summits of the sandstone ridges between Lewistown and Shirleysburg. The ore banks at present worked are in these positions. The ore occurs in Little Cove, and at Pennock's furnace in Huntingdon county, in precisely the same geological relations; but to what extent it prevails throughout the long line of intermediate country, nearly thirty-five miles in length, we have at present no means of ascertaining.

Strata of very analagous ore exist on the flank of Dickey's mountain, near Hanover furnace, and, we have reason to believe, range very extensively in this part of the series. Ore of the same cellular structure as that above described, is visible in a similar position on the flanks of Cove mountain, and on the north flank of Stone mountain. Its place in the strata is a short distance above the thick mass of red shale in the upper half of F. V. It is not to be confounded with the fossiliferous ore, already mentioned, which occupies a lower position, being among the calcareous shales nearer the middle of the stratum.

Iron Ore of F. IV. on Black Log Mountain.

There is a deposite of stalactitic iron ore occuring in a transverse fissure near the crest of Black Log mountain, four miles south-west of Rockhill furnace. The adjoining rock is the upper white sand stone of F. IV. The ore is of a brownish black colour, and of a cellular and stalactitic structure. It is rich, easily reduced, and produces a red-short iron. The rocks of F. IV. here are reddish, being tinged with oxide of iron, the solution of which is probably the source of the deposite.

FORMATION IX.—*Red Shales and Sandstones.*

At the passage of the underlying olive slates of F. VIII. into the red rock of F. IX. above, we meet with a thick series of beds, composed alternately of the materials of the two adjacent strata. They consist of buff and olive coloured slates, interstratified with reddish slates of very similar composition. They are highly argillaceous but compact, and offer considerable resistance to denudation. They usually form rounded but continuous ridges, more elevated than the neighboring hills of the olive slate, and give rise to a soil which is well adapted to cultivation. Clear ridge in Hare's valley, and Timber ridge on the north-west side of Licking creek, consist of these beds.

Formation IX. commencing over the synclinal axis in the middle of the basin of Great Aughwick valley, near the mouth of Three Spring creek, gradually expands in its course towards the south-west until about eleven miles from its origin it meets the other belt which ranges along Hare's valley, and follows the base and flank of Sideling hill. The two compose then a track several miles broad, in which the anticlinal axis of Jack's mountain gradually flattens down or expires. The strata now gradually assumes throughout, a north-west dip, when the belt contracts and ranges thence, with great regularity, to the south-west, along the base and slope of Sideling hill, until it reaches the Potomac. The sudden narrowing of the belt occurs opposite to a curvature in the anticlinal axis which extends from Black Log valley into Pigeon cove; but the cause of this curvature, and of the diminished breadth of F. IX., is manifestly the sudden subsidence of the Jack's mountain axis of elevation.

Another considerable belt of F. IX., occupies the principal part of Big Scrub ridge, where it supports, in the form of a basin, resting on an elevated table land, the overlying grey sandstone of F. X. and the still superior red shales of F. XI. Commencing north of Harshy's mill, in the synclinal axis north-west of Little Scrub ridge, this tract of red rocks of F. IX. immediately widens out, and four or five miles to the south-west embraces the table land of overlaying rocks referred to, which divides it into two nearly parallel zones. That on the north-west, forming part of the licking creek settlement, exhibits the strata at the base and on the north-west flank of Big Scrub ridge dipping thirty degrees to the south-east. The other belt follows the south-east base and flank of the ridge, and has its strata in an almost perpendicular altitude, uptilted by the prodigious pressure exerted along the great dislocation in the formation at the base of Little Scrub ridge. Between six and seven miles from their point of separation, these two belts of F. IX. reunite, the upper harder beds of the stratum forming the summit of Big Scrub ridge for several miles further to the south-west, beyond the termination of the sandstones of F. X.—The whole belt of F. IX., about two miles in width. continues towards the south-west until it reaches the Potomac several miles below Hancock—its beds on the south-east dipping steeply north-west, and those on the opposite side gently towards the south-east.

Formation X.—*Coarse Grey Sandstone and Conglomerate.*

This rock, besides forming the summit of Sideling hill throughout its entire length from Terrace mountain at the Juniata to the Potomac, forms the table land of all the central portion of Big Scrub ridge. In this latter mountain, it contains a synclinal axis, and forms, therefore, a trough or basin, which is about six miles long and one wide. Within this basin is a rather curious elevated little valley, the surface of which is about three hundred feet below the crest of the sandstone ridge which every where surrounds it. From the outer base to its summit, Big Scrub ridge is about eight hundred feet high The beds of conglomerate have a perpendicular dip on the south-east side, and on the north-west a gentle inclination of thirty degrees to the south-east. The little synclinal valley, covered by an extensive meadow, is drained by a defile or gorge in the perpendicular wall on the south-east, where the stream called Tumbling run finds its course impeded by a succession of waterfalls.

FORMATION XI.—*Red Shale.*

The small valley on the top of Big Scrub ridge is formed by a belt of F. XI., about five miles in length and six hundred yards in breadth, encircled by a perpendicular strata on the east, and more gently sloping ones on the west. This tract is called the "meadow grounds," and is resorted to, at proper seasons, as a natural pasturage for cattle.

The broad valley lying south-east of Sideling hill, from the general poverty of the soils of F. S. VIII. and IX., is a sterile district, thinly settled. Its physical features are those of a rolling, hilly surface.

Iron Ore near the contract of F. IX. and F. X.

Rather more than two miles from the north-east extremity of Big Scrub ridge, a small deposite of iron ore occurs on the north-west flank of the mountain. It is associated with the sandstone which lies but a short distance below the conglomerate belt of F. X., and which form a range of cliffs along all this side of the ridge. Though not abundant, the ore is interesting from its beautiful structure. It is a fibrous, radiated hematite, arranged in parrallel cylinders or stalactitic rods. These cylinders seem all to have been pendent, like icicles. It lies loose at the base of a precipice of the argillaceous sandstone, having apparently fallen out of a cleft or fissure in the stratum.

M'Connelsburg Cove.

This is a little valley of elevation, consisting, in its centre, of F. II., the great limestone formation near the base of our lower secondary series. It is bounded on the south-east by the main Cove mountain, and on the north-west by the Scrub ridges. Nearly opposite M'Connelsburg, Little Scrub ridge, extending from the Burnt Cabins, ends; and six miles to the S. S. W., near Hunter's mill, another ridge, called Dickey's mountain, rises to occupy the same range. These two ridges are prolongations of the same belt of the white sandstone F. IV. which between them has been heaved down to a great depth by an enormous dislocation which extends for at least twelve miles along the north-west side of the cove, burying the strata which ought naturally to occupy the surface under more than two thousand feet of other rocks inverted over them, and bringing, in one place, Fs. II. and VIII. violently into contact.

Limestone F. II. and its Anticlinal Axis.

The limestone of the cove consists of alternating beds of pure blue and siliceous limestones, and whitish magnesian limestones adapted for making *hydraulic cement.* The upper layers, adjoining the overlying slate, embrace dark calcareous slates and black limestones, but without that profusion of fossils which these layers contain where they are exposed in some of the limestone vallies to the north and north-west.

The limestone is traversed by an axis of elevation which ranges somewhat centrally along the valley, and passes directly through M'Connelsburg. Its regularity is somewhat disturbed by the contiguity of the great fault or dislocation on the north-west.

Dislocation along the side of the Cove.

The rocks composing Little Scrub ridge, and ranging along both sides of it, are, for the first five or six miles of its course from the north-east, in their proper relative positions, though slightly overturned or inverted as far to the south-east as the position of the anticlinal axis. Such is the state of things at Harshy's gap. About two miles further to the S. S. W., or seven miles from the Burnt Cabins, the great fault commences, running parallel with the ridge. The adjoining limestone on the north-west side of the cove begins to assume its natural dip towards the north-west, becoming less inclined as we trace it to the S. S. W. Presently, however, the slate F. III. disappears—then F. IV. the sandstone constituting Scrub ridge, dipping now eighty degrees to the south-east. Here all the upper portions of F. V., the limestone F. VI., the sandstone F. VII., and a large part of the slate F. VIII., all vanish—the rest of F. VIII. dipping, like the sandstone F. IV. in contact with it, eighty degrees to the south-east. The strata F. S. II., III., IV., V., VI., VII., and VIII., have all been broken off and heaved down on the north-west side of the fracture, leaving only a wedge-shaped mass of F. IV. composing the remnant of Little Scrub ridge, filling the fissure between F. II. and F. VIII. This unconformable fragment of F. IV. is much shivered and polished by the enormous crushing force to which it has been subjected.

About three miles further to the south-west, opposite to M'Connelsburg, the same condition of things still exist, only the limestone F. II. dips more gently to the north-west, and a larger portion of F. VIII. has been cut off by the fault. Little Scrub ridge ending at this place, the limestone F. II. abuts directly against the slate F. VIII., the latter bounding, in reality, the cove, though the mountain a mile to the north-west, called Big Scrub ridge, already described, is generally considered as the boundary. Tracing the fault for several miles to the south-west, the limestone in contact with it becomes less inclined to the north-west, while the remnant of F. IV. occupies the fissure at intervals, forming at several places a low and obscure ridge. At Rankin's clover mill, four miles to the south-west, at the termination of Little Scrub ridge, the limestone adjacent to the fault dips to the opposite quarter, or the south-east. From this point two miles south-west, to Hunter's mill, situated immediately on the fault, the same state of things prevails, F. VIII. beginning to emerge. A little south-west of Hunter's mill, the sandstone F. IV. rises into Lowrey's knob, and continues thence to the south-west in a ridge, called Dickey's mountain—the other formations emerging on the western flank of Lowrey's knob. Here Fs. V., VI. and VII. appear in a perpendicular attitude; and along the south-east side of the knob lies a portion of the slate F. III., with its beds in great confusion. At *this* point is a rich and valuable deposite of *iron ore*, attached to Hanover furnace.

The ore lies in the clayey soil over the crushed slate, and seems to have been collected here from the filtration of the ferruginious matter out of the sandstone of the knob which rises close at hand in a steep slope. Opposite to the knob the anticlinal axis of the middle of the Cove disappears being obliterated by the upheaving of that part of the limestone which lies south-east of the fault. Further towards the southwest, the dislocation becomes itself an anticlinal axis, the same which elevates the strata in the south-west end of the Cove. In this part of the Cove, the rocks on the north-west side of the axis are perpendicular while those on the south-east side incline gently towards the base of the Cove mountain. The limestone beyond this is overlaid across the axis by slate which forms the head of the valley towards the south-west, which is soon after closed by the union of the Cove and Dickey's mountains.

F. III. Slate.

The slate F. III., is a stratum of considerable thickness in the Cove, covering the north-east end of the valley for several miles, the belt dividing where the limestone is protruded to the surface. The western belt keeps along the base of Little Scrub ridge until it is lost in the fault. The eastern one bordering the Cove on the flank and at the base of Cove mountain is nearly half a mile in breadth. It dips uniformly to the E. S. E. thirty degrees, and ranging southward meets the western belt which emerges from the dislocation near Hunter's mill, and ranges about three and a half miles to their junction. After their union, the general belt of slate covers the southern end of the valley called the *corner* of the Cove, for three miles. In consequence of the profusion of the debris from the adjoining sandstone mountain, which here forms the soil, this part of the valley, is almost incapable of cultivation.

Iron Ore of F. III.

The ore bank of the Hanover furnace occurs on the south-east side of Lowry's knob, just where the slate F. III. emerges from the

Scrub ridge fault. The slate is much contorted, and crushed in places into a clay into which the ore has been lodged. At the outcrop the ore formed a thin waving layer which traced into the side of the hill assumed a perpendicular direction and became much thicker. It lies surrounded by clay, that beneath it being very unctious and beautifully colored. The ore is much used. It occurs ofted in angular masses of considerable size, having a fracture or cleavage similar to that of the adjacent clay. It is compact and ponderous, has a dark reddish brown color, and is as rich as the *hydruted brown ores* generally are, which are derived from this formation. Its aspect and composition are however somewhat variable. Smelted with the cold blast it makes a good malleable iron a little *red short*, or not welding with facility at a red heat. The analysis in chapter VI. will display the average composition of this interesting ore.

The clay underlying it is different from that above it, being almost impermeable to water, and hence the effectual manner in which it has arrested the *oxide of iron* percolating from above.

Formation IV. White Sandstone.

In the Cove mountain and neighbouring ridges, F. IV. does not retain the tripple subdivision to the extent which it exhibits in the mountains further to the north and north-west, and hence we do not find its ridges here, possessing the double summits which characterize those of other districts.

Little Scrub Ridge, commencing in Sidney's knob at the Burnt Cabins, is there of the usual elevation of the mountains of F. IV., but advancing towards the south it declines in height and assumes an undulating summit. This is in part owing to the increasing steepness of the strata. The belt ends as before described by disappearing in the fault opposite M'Cononelsburg, and appears only at intervals in three or four places for six miles to the south, lying as a detached mass in the fault. Reaching the surface again in Sidney's knob, the sandstone soon swells into a mountain of considerable height, which reaching the Maryland line sweeps eastward and terminates in the end of Cove mountain.

The Cove Mountain, commencing at Sidney's knob, bounds the eastern side of the Cove, and runs in a nearly straight line south, until opposite M'Connelsburg, embracing between it and the southern continuation of the Tuscarora mountain a norrow trough or synclinal axis which there closes up. Beyond the junction, the mountain sweeps to the south-east, the Chambersburg turnpike ascending its flank. By the curve in the mountain, the Cove is considerably widened. Near the curve terminates the anticlinal axis of the Tuscarora mountain. The Cove mountain now assumes its proper direction to the S. S. W., and gently curving south and then westward finally unites with Dickey's mountain not far from the State line. Its rocks dip uniformly towards the E. S. E. thirty degrees.

About two miles north of Louden, a synclinal axis or trough originates on the eastern side of the Cove mountain in F. IV. Expanding towards the south, this trough becomes the basin called the Little Cove, the western ridge of which runs south, as the prolongation of the Tuscarora and Big Cove mountain, and the other running S. S. W., becomes the Little Cove mountain, bounding the valley west of Mercersburg. The formations together with their ores which compose the Little Cove basin have been already described with sufficient fulness for the present

SECTION III.

Kishicoquillas Valley.

Kishicoquillas valley, the next belt of country towards the north-west, beyond the Lewistown valley, extends through parts of Mifflin and Huntingdon counties, from north-east to south-west, having a length of nearly thirty miles, and a breadth varying from two to four miles. Nearly the whole area of the valley consists of fertile land, some of which is under high cultivation. It is a beautiful instance on a large scale of what is termed in geological language a *valley of elevation.* The bed of the valley consists of Fs. II., and III., uplifted to the surface by several anticlinal axes and the whole bounded by mountain ridges composed of the less destructible sandstones of F. IV. The surface of the valley in its highest portion around Allenville, is elevated three hundred and fifty feet above the Juniata, at Lewistown. It descends gently in all directions from this central district. Two deed gorges or gaps in the belt of mountains which encircle it, admit us into this valley. One of these called Brown's Gap, is in Jack's mountain, its general south-eastern boundary. Through this passes Kishicoquillas creek. The other Gap is in Stone mountain, which encompasses the valley on the north-west. This is at its eastern extremity, and affords an outlet for Goslin run. The two mountains which confine the valley are *Monoclinal Ridges*, that is to say their strata dip in but one direction, those in Jack's mountain dipping to the south-east, and those in the Stone mountain to the north-west. After ranging for many miles to the south-west, and gradually converging, these mountains fold together over the anticlinal axis of the valley, and thus shut it up. The anticlinal axis then ranges along the summit of Jack's mountain to its termination near the Three Springs in Huntingdon county.

Limestone F. II.

The lowest strata of the great limestone formation which have been brought into view near the centre of the valley, by uplifting agencies, consist of blue limestones, some pure and some siliceous, alternating with lighter coloured greyish-blue magnesian limestones, nearly of the composition called dolomite. A little higher in the formation, these magnesian beds constitute a thick belt; while above them, bluer and more purely calcareous limestones succeed, supporting, in their turn, a mass of dark argillaceous limestones and nearly black calcareous slates, the latter often highly fossiliferous. These upper layers mark the passage of the limestone into the overlying slates of F. III.

Slate F. III.

The slate F. III. encircling Kishicoquillas valley ranges in two belts. That on the south-east follows the base and slope of Jack's mountain, spreading usually from the ridge a few hundred yards into the valley and rising more than half way up the acclivity. The other belt, on the north-west, leaving the subordinate vallies between the knobs at the north-east end of the principal valley, ranges along the base of the Seven mountains, and then along that of Stone mountain, until it meets the other belt connected with Jack's mountain, when the two occupy the south-west end of the valley for more than a mile. The slate again shows itself on the Juniata, at Drake's Narrows, four miles beyond, having passed out of Kishicoquillas valley under the axis of the mountain. Opposite Greenwood, the slate expands further into the valley, in consequence of a dislocation of the strata in Stone mountain. This part of the belt, several miles in length, is three-fourths of a mile broad. Further to the south-west, it resumes its usual position near the base of the ridge, but extends high up its slope owing to the gentleness of the dip. Still further to the south-west, it becomes perpendicular; and about seven miles beyond Allenville, joins the south-eastern belt over the anticlinal axis.

At its north-eastern extremity, Kishicoquillas valley is subdivided into three lesser vallies, by the commencement of two synclinal ridges, locally called knobs. One of these little vallies destitute I believe of a name, lies between the Seven mountains and Baird's knob, and is prolonged to the north-east between the former range and Stewart's knob. The central one lies between Beattie's and Stewart's knobs, and is called Orr's valley. The third or most south-eastern is included between the southern or Beattie's knob and Jack's mountain. These conspicuous knobs are high ridges of regular synclinal structure, appearing, when seen from a distance, to consist each of a high central ridge and two outer ones in the form of broad and very regular terraces. The northern knob, called Stewart's, is on the same range with Baird's knob, the two occupying one synclinal axis.

The limestone ceases about one hundred yards south-east of Greer's tavern, and about five hundred yards from the base of Jack's mountain. Its north-western margin is near the furnace and a little south-east of Thompson's tavern. The formation extends to the north-east a short distance beyond Sterrett's mill, where the upper or fossiliferous layers show themselves. The limestone itself is not developed in the small valley between Jack's mountain and Stewart's knob. It sweeps round Beattie's knob, and in a rather narrow belt ascends Orr's valley to within one mile of Mr. Solomon Close's, the last farm house between the knobs. It does not pass round Stewart's knob, as the synclinal axis of that knob carries a trough of slate throughout the whole distance between it and Baird's knob, south-west of the turnpike. The only part of F. II. developed in the valley to the north-west of this synclinal axis, is the fossiliferous portion, consisting of the uppermost layers which are well exposed on Mrs. Christman's farm.

Anticlinal Axes of the Valley.

The axes which have protruded the limestone to the surface, are not of that symetrical structure found in vallies of elevation of a simpler form; for instead of the strata dipping in both directions away from the central line, the two sets of dips are often towards the same quarter, those on one side of the axis being *inverted.* This inversion occurs almost in every instance on the north-west side of the anticlinal axes. Even when a part of the strata have not been averted near an anticlinal axis, those on the N. W. exhibit with a few exceptions, a steeper dip than those on the S. E. These striking features point to something very peculiar in the mode in which our rocks have been elevated by subterranean forces and seem plainly to indicate that the uplifting pressure was not strictly vertical, but exerted, from the N. E. toward the S. W. The probable cause of this will be discussed in my final report.

An anticlinal axis traverses the little valley between Jack's mountain and Beattie's knob. It dies out between four and five miles north-east of the turnpike. Another anticlinal axis follows near the middle of Orr's valley between the two knobs, being visible on the main road leading up this valley, as far as the uppermost *sink hole.* This axis is prolonged to the southwest, passing, apparently one-third of a mile south-east of Perryville. A third anticlinal axis ranges immediately to the north-west of the last and parallel with it, running also to the mouth of Orr's valley or to the south-east of Stewart's knob. The rocks on the north-west side of this axis show an inverted dip or incline to the south-east. This is clearly seen on a farm half a mile east of Perryville, where the beds on the south-east side of the axis incline thirty degrees to the south-east; and those on the north-west, seventy-five degrees to the south-east. The very line of the axis is discernable in a broad *sink hole* immediately north of M'Dowell's house. It probably dies out in Orr's valley about one mile above its mouth. This last axis, extending along the north-west side of the general valley near the base of Stone mountain, terminates a short distance south-west of Sinkey's gap.

On the south-east side of the valley, another more extensive line of elevation in the limestone commencing three miles south-west of Brown's Gap, and extending to the south-west, becomes the main central anticlinal axis of the valley, and afterwards of Jack's mountain in Huntingdon county. The ends of this axis and that before described as lying near the base of Jack's mountain pass each other, the overlapping extremities being nearly two miles apart. Between these extremities terminate the two other axes first described, that of the Little valley south-east of Beattie's knob, and the south-eastern or longer one, of Orr's valley. The anticlinal axis nearest to Stone mountain, has its strata on the north-west, overturned as already mentioned. The main axis nearest to Jack's mountain extends for many miles parallel to its base from which it is about a mile distant. To the soth-east, of Greenwood, it exactly coincides with the line of valuable *ore banks*, and at Allenville shows itself about midway between the town and the foot of Jack's mountain. It ranges regularly on towards the S. W. between four and five miles, preserving a uniform and moderate inclination in the strata on both sides of it until the gradual bending round of Stone Mountain brings it against its base. Here it assumes a sudden change of direction, curving towards the S. S. W. to run parallel with the foot of that ridge. The rocks on the N. W. side of the axis previously at a gentle dip, now become perpendicular, and continue thus to the termination of the valley, when it passes under the summit of a broad and lofty ridge formed by the union of Jack's and Stone Mountains.

Iron ore of Kishicoquillas Valley.

The iron ore of this valley is the usual cellular and stalactitic brown ore of the limestone districts. It occurs in irregular nests and layers in the ferruginous loam and clay overlying the limestone to which it seems to bear no fixed relation. Its discovery is therefore a matter almost entirely empirical. In Kishicoquillas valley, however, its distribution is so dependant on the geological structure of the belt, that its range already ascertained by excavations, can be laid down with great precision. All the ore deposites hitherto wrought *occupy the lines of elevation* of the limestones, occupying exactly in the fissure formed by the angular bending of the strata, over the anticlinal axes. It seems probable that no valuable body of ore has been deposited in any other position in the valley. Immediately upon the anticlinal axis which comes out of Orr's valley, and becomes the second one south-east of the foot of Stone mountain, there is a considerable deposite of *iron ore* wrought at Davis's bank. But it is in the fissure of the main axis or that nearest Jack's mountain, that the best ore deposites lie. A little south-east of Greenwood, there is a line of excavations from which large bodies of ore have been taken. The principle banks are those of Messrs. Holliday, Hall and Rawle, and Patton & Co. Little doubt can be entertained that ore of the same quality exists at various other points on the line of the anticlinal axis, both north-east and south-west of these openings. Promising indications of the ore were witnessed on several farms precisely in the range, as ascertained from other independent proofs, of the fissure along the line of the axis.

The evidence of the existence of ore in sufficient quantity towards the north-east end of the valley are by no means obvious, only a single bank being extensively wrought. This lies about four miles from Perryville, on the farm, I believe, of Mr. Samuel M'Nitt. Its position is upon the crushed anticlinal axis already described, as terminating near the mouth of Orr's valley. This ore is no longer used, owing to too large a quantity of *sulphuret of iron*, which is intermixed with it. I conceive that though the promise of ore in this section of the valley is not inviting, the best chance of obtaining it, is in the line of country immediately contiguous to the range of the crushed anticlinal axis which extends from M'Nitt's to Perryville.

FORMATION IV.—*White Sandstone.*

This stratum retains its triple character in the mountains bounding Kishicoquilles valley, though less distinctly than in the ridges further towards the north-west. The softer and more argillaceous nature of the middle member of formation has given rise by denundation to a bench or elevated terrace on the flanks, not only of Jack's and Stone mountains, but also of the knobs. This has been erroneously conceived by some to mark the shores of a supposed lake, of the existence of which we have no evidence whatever.

Stone mountain, has a sharp narrow and regular crest throughout the greater part of its length. A notch, or depression in the ridge between three and four miles south-west of Milligan's knob, is called Sinkey's gap. The terrace on the side of the mountain from this gap for several miles to the south-west, is about a fourth of a mile wide, and is trenched by a number of deep ravines on the flank of the mountain. It becomes wider near a great fracture in the chain opposite to Greenwood. This fracture or fault occurs where the road leads across from Greenwood into Stone valley. The main crest of the mountain consisting of the upper member or white sandstone of F. IV. suddenly ends, and another ridge, the crest of which is formed by the same upper sandstone, dipping in the same direction, steeply to the north-west, commences northwest of the former at Greenwood furnace. This latter mountain continues south-west as the main Stone mountain, its terrace soon becoming regular and nearly a third of a mile wide. The two crests of the dislocated ridge pass each other, overlapping nearly a mile and a half. The line of dislocation intersects the mountain obliquely, having a N. N. E. and S. S. W. direction, and the rocks to the north-west of it have been heaved up past those on the south-east, so as to dip in the same direction—it is only towards the south-western end of the fault, that the strata on the south-east side dip away from the dislocation. Beyond Allenville to the south-west, the terrace on the flank of the mountain becomes three-fourths of a mile broad. The Rocks of the Lower sandstone division F. IV. form the brow of the shelf, with a less steep inclination than those of the upper division in the crest of the ridge. Still further to the south-west towards the termination of the valley, the rocks becoming more perpendicular, this terrace grows proportionately narrower, and is at last hardly perceptible.

Jack's mountain, bounding the valley on the south-east side displays great regularity in its contour. Its crest or summit is nearly straight, consisting like that of the Stone mountain, of the upper hard sandstone of F. IV. Its strata, generally incline to the south-east, very uniformly at thirty degrees dip. Towards the south-west the mountain gradually sweeps round more to the south, making a convex curve on the side next the valley. Its terrace usually between three hundred and four hundred yards broad, widens near Allenville, and becomes gashed by deep ravines, exhibiting great uniformity of outline, at distances averaging a third of a mile. Beyond the point, where it coaleces with Stone mountain, the ridge assumes the anticlinal structure, though the rocks of the opposite flanks retain nearly their previous dip, that prolonged from Stone mountain, forming the north-west side, being nearly perpendicular; while those continued from Jack's mountain slope to the south-east, at an angle of twenty-two degrees. The broad and majestic ridge thus composed, traverses Huntingdon county, and terminates near the Three Springs, undergoing a gradual flexure to the south as it proceeds.

The next belt of country, proceeding to the north-west, is that of the Seven mountains; but as a general discription of this wild unpopulated district, was given in my last annual report, and as a detailed and full account of it can only be rendered intelligible through the assistance of a geological map and sections, I deem it best to postpone publishing the result of our examinations until the appearance of my final report. I shall therefore offer some details, intended to show the resources and structure of Stone valley, and the general belt of formations ranging from the Seven mountains to the south-western side of the Juniata.

Stone Valley.

It will be convenient for the sake of brevity, to extend the name Stone valley to the whole district embraced between Stone or Jack's mountain and Tussey's mountain, as far to the south-west as the Juniata, though that portion which lies between Warrior ridge and Tussey's mountain, is sometimes called the valley of Shavers creek. This subordinate valley, extending to the south-west side of the Juniata, assumes the name of Hartzlog valley, and afterwards, from the knob of Tussey's mountain, five miles from Alexandria, onward to the south-west, it takes that of Woodcock valley.

Confining our attention for the present to the general valley north-east of the Juniata, we may consider it as one broad basin traversed by a principal synclinal axis, extending from the coal basin of Broad Top mountain, through Terrace mountain, and through this valley, and finally through Milligan's knob, and thence by Stewart's knob to the Susquehanna. The slate ridges, which range from the south-west, following, respectively, the bases of Terrace mountain and Sideling hill, unite in the central part of what we term Stone valley. Outside of these, Warrior ridge and Rocky ridge, form two belts of the sandstone F. VII. and unite like the slates, but at a point further to the north-east. Encircling the sandstone of these ridges, are the next lower rocks of F. VI. and F. V., ranging together in a belt along the base of Stone mountain and at the foot of Tussey's. These, by their union, form the head of the valley, F. V., folding over the spurs prolonged from the chain of the Seven mountains.

The only portion of the district, which requires from its intricacy, a minute and detailed investigation, is the belt composing the Warrior ridge and the valley between it and Tussey's mountain. This part is traversed by many parallel and even overlapping axes of elevation. F. V., folded round most of these axes, the *fossiliferous iron ore* is brought to the surface, and therefore much research has been necessary in tracing the exact features of this section of the valley. The general synclinal axis of Stone valley, lies about four and a half miles from the foot of Warrior ridge, and two and a-half from that of Rocky ridge. The inclination of the strata on the two sides of this axis, is nearly equal, being not more than from ten degrees to fifteen degrees. Further to the north-west, the dip augments to twenty-five degrees, and again diminishes as we approach Warrior ridge, it being about five degrees where the Juniata intersects the sandstone. On the other side, towards the north-east, it becomes thirty-five degrees as we recede from the middle of the basin to the first hill, parallel to Sideling hill; while in the next belt of slate hills, belonging to F. VIII., the dip to the north-west becomes seventy degrees, and at the Gap in Rocky ridge, the sandstone F. VII., is nearly perpendicular.

The physical features of Warrior ridge, are somewhat peculiar, though its structure is simple and easily explained. Opposite Huntingdon and Petersburg, it is a broad table land, the sandstone F. VII. capping its summit. Along the top of the ridge and in many places at its flanks, it is gashed by deep ravines. The strata are not quite uniform as to dip, undulating gently in consequence of the dying out of some of the axes of the Seven mountains. Towards the north-east, the dip augments, and the ridge accordingly becomes narrower, the sandstone occupying then only the south-east half and the underlying limestone, F. VI., the north-west. Formation VII., curves round to meet the corresponding sandstone of Rocky ridge, about sixteen miles north-east of Huntingdon; from the Juniata, Warrior ridge contracts in breadth also towards the south-west, its strata here being beyond the influence of any axes tending to hold them up in a wide belt.

The several formations, occupying the broad basing before us, are so analagous in aspect and composition to the belts of the same already described in the Lewistown valley, that a passing notice of them in this place will suffice. Formation IX., consists of red sandstone of various shades of colour, alternating with layers of red shale. Formation VIII. embraces much grey sandstone, and towards its upper portion, some beds of a very massive greyish blue variety. These last are quarried near the canal below Huntingdon, and supply an excellent building stone. Beds of superior flag stone occur in the alternation of F. VIII. and F. IX. The general character of F. VII. is that of a white course sandstone, which readily disintegrates by exposure. The roads on Warrior ridge are frequently covered with sand to the depth of several inches. The sandstone being intersected by a system of regular and extensive joints in plains nearly perpendicular to the bedding of the rock, and being at the same time thus easily weathered, its blocks sometimes assume singular and grotesque forms, standing forward in crags or rising in remarkable columns. The Pulpit Rocks, near Huntingdon, are an instance of the joint operation of the two causes mentioned.

Some of the beds of this formation, furnish a material admirably fitted for the hearth stones of blast furnaces. The hearth stone of Mill creek furnace is procured from Rocky ridge.

The limestone F. VI. possess very nearly the same features which distinguish it in the Lewistown valley. An ash-colored and very argillaceous variety occurs near its passage into the underlying shales of F. V. This is not adapted either for burning for lime, or for building with. When newly taken from the earth, it has a rather durable aspect, which has occasionally deceived the engineers who have used it in the construction of aqueducts, and other important structures on the canal. It is well exposed three hundred yards below the forge at Petersburg. These alternating rocks between F. V. and F. VI. are very thick, and comprise many of the hills north-west of Warrior's ridge. When tracing the *fossiliferous iron ore* of F. V., I shall allude to the beds of that stratum, more particularly of the portion connected with that valuable layer of *iron ore.* Formation V. occurs in the flank and at the base of Stone mountain, where, however, the ore bearing portion of the rock does not form a distinct ridge. The belt continues for nineteen or twenty miles to the north-east from the Juniata, and then expands from the head of the basin between the Stone and Broad mountains. Ranging north-east of Greenwood furnace, it folds round the end of Broad mountain, taking an anticlinal form which throws up the ore in a chain of elliptical hills, where it is dug at the ore banks of Messrs. Alexander and Diarmid. In this manner it winds round the end of all the ridges of F. IV. between Broad mountain and Tusseys mountain, making its south east boundary the north-west base of Warrior ridge, and then occupies the valley of Shaver's creek, and its continuation to the north-east, ranging also to the south-west into Hartzlog and Woodcock vallies. This wide belt embraces many anticlinal axes, between which lie the rocks of F. VI. and F. VII. These spread out the formation in many changes of dip, causing chains of hills, in which the fossiliferous ore crops out upon the surface.

Iron Ores in Stone Valley.

About one mile south-east from Mill creek furnace, a deposite of ore occurs overlying F. IV. on the summit of Jack's mountain, which deserves mention from its peculiar position. From the ore digging, a ravine runs up the slope of the mountain towards the east, on the north-west side of which occurs a ridge, embracing the upper sandstone of F. IV. The ore is on the very edge of the summit of the mountain, where it has been reached in a shaft of some depth, which terminates in a sandy clay containing the concretions. Reflecting on the circumstances which have given rise to this deposite, one can hardly resist the persuasion that a large bed of ore in this situation is rather improbable, and that its present sandy character will not give place to a purer one, when the mass shall be penetated deeper.

The fossiliferous ore of F. V. merits much more attention, and deserves a diligent examination by mining, on the part of those interested in this valuable mineral. Though only one or two openings have hitherto been made in the bed, our efforts to trace it were in some degree crowned with success, owing to the useful clue afforded by a previous investigation of the range of the several axes or lines of elevation, and of the precise place in the formation to which the ore appertains.

The lower shales of F. V. are olive and yellowish; those adjacent to the ore are of a deep buff color. Over these are layers of a hard white or greyish-white sandstone, breaking into rhomboidal fragments. This rock, which is not always present, is distinguished by its abundance of fossil *encrini*. Its thickness is less than in the Lewistown valley, but its fragments are more scattered at its out-crop at the surface, in consequence of its inferior hardness. The weathered pieces have a rotten, worm-eaten aspect, and a dirty yellow color.—This rock is well known throughout the valley, and I therefore wish to attract especial attention to it as the best guide I can suggest to the position of the ore. It will be remembered that in the Lewistown valley a similar encrinitic sandstone occurs invariably just below the ore; here, on the other hand, it seems to *overlie* it. The reverse of this order of things prevails, however, at one of the excavations undertaken for Messrs. Dorsey and Green, not far from the passage of the Little Juniata through Tussey's mountain, the ore here seeming to rest above the sandstone, as in the Lewistown valley. The ore has been opened to the north-east of Dorsey's forge, in the south-west flank of a hill running parallel to Tussey's mountain, in strata dipping twenty-five degrees to the south-east. The bed is nearly eighteen inches in thickness, and the ore is of the hard calcareous variety. It shows the usual rectangular fracture, and is of excellent quality. The analysis to be found in Chapter VI., will show its composition.

Directly under the ore lies a bed of olive colored slate, supported by a massive stratum of hard encrinitic sandstone. Higher in the same hill, the weathered fragments of the sandstone are abundant. The position of the seam of ore is not favorable to its being easily excavated, and the narrowness of the summit along which its out-crop lies, preventing a sufficient percolation of water, has caused the ore to retain its original compactness and calcareous nature, even near the surface where usually, under more propitious circumstances, the ore is soft and porous.

On the same ridge with the above, between the Little Juniata and the Pennsylvania canal, Messrs. Dorsey and Green have made three or four openings, The most important is the one furthest north-east, where the vein is *a foot thick*, exhibiting some variety in composition and hardness; the hard *calcareous variety* lies above, then another less hard, and a third kind which is quite soft, apparently resulting from the decomposition of the harder variety, succeed. Under this seam occurs the massive *encrinitic sandstone*, occupying a different position from that which it usually observes further to the north-east in this belt. The dip being steep, the most eligible mode of mining it would seem to be to cut a tunnel to it from the base of the hill. Dr. Dorsey has excavated for the ore along the base of Stone mountain, and finds it of insufficient thickness to be valuable. It has been partially opened on the canal, where it is four inches thick, dipping seventy-five degrees to the north-east, and separated from the red shale in the upper division of the formation by two hundred and twenty-five feet of olive, buff and other colored slates. It has been opened elsewhere in the same range, at points where its thickness continues inconsiderable.

Further towards the north-east, the fossiliferous ore has been developed by Messrs. Alexander and Diarmid, in a hill of F. V., which terminates near the furnace, and which curves westwardly and joins another hill on the opposite side of the point of Broad mountain.—Where the stratum expands at the junction of these two hills, the ore has been opened. Fragments of the ore occur abundantly on the surface, but the seam is not visible in several little shafts which were dug a considerable time since. The presumption is, that the bed, if reached at all, proved too thin. At this place the ore probably overlies the buff shales, visible in the shafts. On a road crossing the hill, and at a lower level than these excavations, the ore bed has been opened, dipping nearly to the west; at one spot, where the bed reaches the surface, it appeared, when fairly developed, to be two and a-half feet thick, though at a place thirty feet from this, where it lies under a deeper cover, it is about twenty inches in thickness. The ore at this place is certainly of excellent quality, containing much of the softer variety, near the outcrop, in consequence of the gentleness of the dip, which does not exceed fifteen degrees to the west. The above openings, constitute the only localities in the valley where the ore has been dug, though we have traced it in many places on the surface, where the indications are favourable, both as to quantity and quality, taking care in all cases to direct the attention of the owners of the tracts to its concurrence. The localities will be mentioned in another place.

The openings made by Dr. Dorsey are the only ones where the ore was detected along the base of Jack's or Stone mountain. The anticlinal axis of Broad mountain prolonged, has caused two hills which contain the ore. It is only at the junction of these that the ore has hitherto been opened; but as these hills continue on both sides of the end of Broad mountain, there is no doubt that the ore can be found in other places on these hills to the east and north-east of the present excavations. The southern hill terminates at the furnace, and it is doubtful whether the ore continues thus far, the strata having been much cut away by denudation. The range of the northern hill is not easily traceable.

The anticlinal axis of the spur of the Seven mountains, next north-west of Broad mountain, in entering the valley, throws up a hill of F. V., disclosing the ore near Mr. Cornelius Davis's. It continues at the surface but for a short distance. No fragments of the ore itself were discovered, but the encrinitic sandstone, and also the olive slate, both indicative of it, are visible. The indications at this spot authorize a search for the ore. The anticlinal axis above mentioned, extends into the limestone of Warrior ridge. The next mountain spur on the north-west, which we shall call the Bear Meadow mountain, divides into three ridges, each containing an anticlinal axis. That next the south has elevated the ore which may be seen a little south of Mr. George M. Bell's saw mill, and which continues thence about a third of a mile north of Ennisville, and directly north of Salsburg. Information that it contained the ore, was important to the proprietors interested, though no particular localities were found where the ore was abundant on the surface; the strata here dip to the south. No difficulty need exist in recognizing the hill, as it is well marked by a profusion of fragments of the *encrinitic sandstone*, in a much weather eaten condition. No prominent hill is here visible corresponding to this, containing the north-west dipping strata of this axis. The same difficulty occurs in tracing the ore hills related to the middle axis of the Bear Meadow mountain, at least none are visible along a section from Enniswille to Steffy's tavern. Crossing the rocks south-eastward, however, a long another line extending from a group of houses, three miles north-east of M'Murtrie's tavern, we detect the encrinitic sandstone. At this anticlinal axis, it is very doubtful, however, whether the ore itself extends thus far. The same axis is observed in the red and green shales above the ore, in a section made south of M'Murtrie's house, beyond which it ceases. The next axis of elevation, is that of the north-western spur of Bear Meadow mountain; this has uplifted the ore in a hill easily recognized. It is about one mile from Steffy's tavern, and has a small shanty at its northern base. Many specimens of the ore were found of a moderately good quality, in an open field belonging to Mr. Steffy, to whom it was pointed out. The same ore is found on the land of Mr. Thomas Blair, a mile and a half from Steffy's, apparently in the same range. It is seen again in the same ridge, a fourth of a mile from Blair's on the farm of Mr. Starr, and might readily be traced through other farms along the ridge, by observing carefully the indicating rocks. Another ore ridge occurs on the north side of Mr. Jonas Rudy's farm, at a little burial ground. This probably unites with the one above mentioned, when the two hills continue as one, passing a few yards south of M'Murtrie's tavern, and dying out between three and four miles further to the south-west. Appearances indicate that the ore is not prolonged as far to the south-west, as where our section crosses the strata, two and a half miles north-east of M'Murtrie's. A few judicious excavations would determine this point.

The next prominent hill containing the ore, runs north of Mr. Jonas Rudy's farm, passing Mr. William Johnson's house, and extending a short distance south of Mr. M'Mahen's, four and a half miles east of M'Murtrie's. It is traceable eastward in the form of an anticlinal hill, to the road leading from Steffy's to Pinegrove, where it divides, the northern spur passing through Mr. Lighteren's land, and the southern running immediately north of Mr. James Leonard's. The axis itself is prolonged into a short ridge of the sandstone F. IV. Throughout most of this part of the belt of F. V. the ore may be sought for with a fair prospect of success.

The next ore hill commences, on Mr. Maffit's place, north of the one last mentioned, his fields showing an abundance of moderately good ore. The belt ranges along the flank of a ridge of F. IV., and extends through Mr. Robert Moore's farm, and thence along the flank of Stoney ridge through lands of Mr. Roberts, the ore appearing in the soil in both places. This ore ridge is joined by another ranging along the north-west side of Stoney ridge, the axes of the two ridges united, being visible in a section from Dorsey's forge to Petersburg, on the east side of the Little Juniata.

The next exposures of the ore are in some low and indistinct hills connected with *Round Knob*, which rises north-east of the forge.—The belt in which the excavation here made occurs, is that on the north-west side of the anticlinal axis of *Round Knob*. This range of ore extends with occasional interruptions along the summit of a ridge of the encrinitic sandstone, which traverses Hartzlog valley, running through a farm belonging to Governor Porter, and thence into Woodcock valley. The information imparted to the proprietors of lands containing this valuable bed of ore, concerning its exact position and range, will incite them, it is hoped, to search for it by actual excavations.

Another but unimportant seam of ore, occurs higher up in the beds of F. V. It has already been alluded to, when treating of the fossiliferous ore of the formation in Lewistown valley, but neither there nor in Stone valley does it promise to be of any value.

Iron Ore in the Limestone F. VI.

Attempts have been made to procure a supply of ore from the limestone belt at the base of Warrior ridge, especially by Mr. Diarmid.—The ore scattered on the surface, resembles somewhat that near the top of Jack's mountain. Some specimens procured from a shaft, seventy feet deep, sunk through sand and clay, were tolerably good; but neither the structure of the ridge, nor the nature of the overlying soil, warrant high expectations of our finding here a useful deposite of good ore. On the same ridge, not far from Couch's forge, fragments of ore of small size are abundant on the surface, and several shafts were at one time dug on a farm belonging to Mrs. M'Gill, but without success. The promise of a deposite of ore of any magnitude in this belt of limestone F. VI. is by no means encouraging.

Clay.

In addition to the ore on Diarmid's place, there is a stratum of white clay, which, according to experiments, seems to answer for the manufacture of fire-brick and crucibles. Specimens were presented to the State cabinet by Mr. Diarmid. It lies in a ravine running transversely to the course of Warrior ridge. Its cover is chiefly sand, derived from the disintegration of the sandstone F. VII.

SECTION IV.

Of the belt of country lying south-west of the Juniata, and between Jack's mountain, and Tussey's mountain.

The next district to be described is the prolongation of the wide belt of the formations which terminate in Stone valley. By the interposition of Sideling hill and Terrace mountain, which terminate together in a high synclinal knob on the south-west side of the Juniata, the general belt before us is divided into three parallel lesser vallies, known as Hare's valley, Trough Creek valley, and Woodcock valley. One principal synclinal axis, traversing the middle of these, or the valley of Trough creek, the same formations rise to the surface in the two opposite vallies of the belt; that is to say, in Hare's and Woodcock vallies, the same rocks dipping to the north-west in the former, which incline to the south-east in the latter. The geology of these two exterior vallies is therefore very similar, while their general structure is remarkably simple. That of Trough creek, on the other hand, is more diversified, and becomes highly interesting when we enter the Broad Top coal basin, which occupies its centre. After devoting a few remarks to Hare's and Woodcock vallies, I shall proceed to describe Trough creek valley, and a portion of its coal field.

Hare's Valley.

The above name is given to the narrow belt included between Sideling hill and Jack's mountain, ending at the Three Springs. Its features are remarkably simple and regular. Sideling hill bounding it on the W. N. W. is a straight ridge of even summit, the outline of which, for many miles from the Juniata, is scarcely varied by a depression. Its eastern side is usually steep, consisting of the red argillaceous sandstone F. IX. for a considerable height. The summit and north-western slope, are formed of the harder grey sandstone, F. X. Clear ridge consisting of the slate, F. VIII., extends continuously through the valley. Its north-west side from the base half way up, is occupied by the lower beds of F. IX., F. VIII. spreading from this margin to the base of Rocky ridge, which is composed of the fossiliferous sandstone F. VII. The little valley between Rocky ridge and the base of Jack's mountain includes the limestone F. VI., and the red and variegated shales F. V. The limestone F. VI. is quarried in a few places; and it may be useful to offer a few hints at present, respecting the position of the purer varieties of the rock. At a quarry about one hundred feet from the east base of Rocky ridge, and near Mr. Humphrey Chilcoat's, the beds exposed, are rather siliceous and abound in fossils. The rock exhaults a fœtid odour when struck. One bed here is of a purer quality. These layers occur near the base of the sandstone F. VII., the purer portions of the limestones lying from twenty to fifty feet further east from the base of Rocky ridge.

Another quarry owned by Mr. Jacob Crotsley, about five miles south-west from Chilcoat's, holds the same position and displays nearly the same layers. In the neighborhood of the present quarries, the underlying layers, it is true, could not be readily reached, but between Chilcoat's and Crotsley's, spots could be selected where they would be accessible.

F. V. and Iron Ore.

No ore is observable in any part of the belt of red shale F. V. until we approach the end of Jack's mountain, where two hills containing the fossiliferous ore arise. That towards the north-west, is crossed by the road leading from Three Springs to Bell's furnace.

The limestone layers of F. V., were only found in one locality, which is in the neigborhood of Three Spring creek, where they are fully developed; some of them consist of good limestone adapted to making lime; others have the siliceous character usual in these beds.

Formation VIII.

Layers of a blue calcareous sandstone passing into a siliceous limestone, occasionally fossiliferous, occur in the lower portion of F. VIII., on the Juniata. This seems to be the representative of the *cement layers*, found in other belts of the formation. A similar bluish calcareous rock, too impure, however, to furnish lime, may be seen on Mr. Crotsley's farm, between his house and Rocky ridge.

Woodcock Valley.

In giving a sketch of Woodcock valley, I shall embrace the whole district included between Terrace mountain on the east, and Tussey's mountain on the west. That portion of this belt lying between Terrace mountain and Warrior ridge, is traversed by four distinct ridges, consisting chiefly of the slate F. VIII. These form a line of bold bluffs on the south side of the Juniata, a little below Huntingdon. The nearest Terrace mountain is called Allegripus ridge. Its summit is broad and undulating, embracing sometimes three minor summits. The beds composing the alternations of F. VIII. and F. IX., appear on the E. S. E. side of the main summit. The Raystown branch of the Juniata, generally flows between it and Terrace mountain, winding circuitously from base to base. Allegripus ridge is a regular range, traceable parallel with the mountain, to a point south-west of Hopewell furnace. Another slate ridge of F. VIII., having no name, lies north-west of Allegripus ridge. This is succeeded by Pine ridge. The fourth ridge, also appearing at the Juniata, ranges immediately south-east of Warrior ridge. It is obliterated occasionally for two or three miles by denudation.

Warrior ridge has been alluded to before. At M'Connelsburg, five miles from Huntingdon, it comprises two summits; but traced further to the south-east, it becomes a single ridge, consisting every where of the sandstone F. VII. In the valley between Warrior ridge and Tussey's mountain, the limestone F. VI., immediately at the base of the ridge, is succeeded by low hills of the coloured shales of F. V., the ore bearing portion of the formation lying adjacent to the foot of the mountain. These low hills result from a series of minor undulations in the strata, derived from the axes of elevation, existing towards the north-east. They are apparent opposite M'Connelsburg, and also in a section made at Mr. Matthew Garner's, twelve miles from Huntingdon; but they disappear before we reach the ore diggings of the Trough creek furnace.

Iron Ore F. V.

The fossiliferous iron ore lies in a ridge containing the encrinitic sandstone which traverses Hartzlog valley, and is prolonged a short distance into Woodcock valley, passing through a series of farms, one of which is the property of Governor Porter. Further towards the south-west, the ore appears near the base of Tussey's mountain, but does not occupy a distinct ridge. It is found at the foot of the mountain, on the road leading from Mr. Matthew Garner's, immediately north-west of the last house. Specimens of the ore—not such, however, as to enable us to judge of its thickness or quality—occur upon the surface.

The fossiliferous ore has been opened to some extent by Mr. Savage, for his furnace, about a third of a mile north-west of the Bedford road, and between fourteen and fifteen miles from Huntingdon. These diggings were prosecuted for about four years. The principal band varies from twenty to twenty-five inches in thickness. The encrinitic sandstone, of a spongy and porous structure at its outcrop, overlies the ore, supporting in turn beds of yellowish slate. The strata here dip about forty-five degrees to the E. S. E. This ore, though belonging to the same belt of F. V., differs slightly in its aspect from that of Montour's ridge, being, on the whole, more laminated and more highly fossiliferous, and probably, at the same depth, somewhat harder.

The next place in which the ore is developed to any considerable extent, is at the openings which supply Hopewell furnace. These are situated several miles to the south-west of the former. Two distinct seams of the ore, separated by eight feet of slate, are stated to occur here—one consisting of the ordinary kind, the other of the hard, calcareous variety. The thickness of each was stated to be two feet. Owing to the want of time, consequent upon the lateness of the season, the mine was not explored. The ridge containing these excavations, sweeps round a knob of Tussey's mountain, and exposes the ore in another place, where it has also been developed for Hopewell furnace—one bed only having been found, however. By entering it at the end of the ridge, a breast of ore, nearly eighty feet from the drift to the outcrop, is made accessible.

The same ore occurs in two ridges between the last mine and that portion of Tussey's mountain through which the road passed into Morrison's Cove. Hopewell furnace has, for some time past; been supplied almost exclusively with this ore.

Trough Creek and Plank Cabin Vallies, and Broad Top Mountain.

The next belt to be considered, lies between Terrace mountain and Sideling hill, and embraces the four uppermost formations of one lower secondary series. The first of these, the grey sandstone and conglomerate F. X. forms the bounding mountains above named. The soft argillaceous shale, F. XI., occupies the general valley between these ridges, surrounding on every side the elevated table land of Broad Top mountain, filling Trough creek, Plank Cabin, Wells and Ground Hog vallies, and the little valley lying between Broad Top and Terrace mountains. Broad Top mountain, comprising F. XII. and the overlying coal measures, rises in the middle of this basin of the red shale in the form of an elevated plateau.

The sandstone F. X., forming the surrounding mountains, is finely exposed in the gap by which Trough creek finds a passage through Terrace mountain at Savage's forge. The strata, which at this place, have a gentle dip, do not exhibit much diversity of character. The lower beds alternating with the upper red layers of F. IX. consists of a coarse grey and yellowish sandstone, of somewhat argillaceous texture, conspicuous, like most other portions of the formation, for its amount of *false bedding*. Overlying this is a stratum of buff colored slate, supporting beds of rather coarse micaceous sandstone, of various tints, greenish, grey and white. Still higher in the series are massive quartzose, white sandstones, stained superfically by iron. Nearly all the rocks of F. X. are more or less ferruginous, containing many specks and blotches of the peroxide of iron, from which certain deposites of ore may have been derived by filtration. In these sandstones we occasionally find small plates or patches of genuine coal, rarely of greater superficial extent than the area of a single flattened stem or leaf of some fossilized plant. We also met with a little black slate. Ascending towards the contact of F. XI., the sandstone once more becomes yellowish and argillaceous, and is surmounted by the red and greenish shales of F. XI., with which these upper beds alternate. In these alternations lies an important bed of *iron ore*, to which I shall presently recur.

Red and greenish shales and argillaceous sandstones of the same colors, occupy the vallies of F. XII. already mentioned. Among the lower layers of the formation, we encounter an interesting band of limestone, found in Trough creek, Plank Cabin, and several of the other red shale vallies. This is probably the equivalent of the limestone, which occupies a corresponding position in F. XI., in the Allegheny mountain and other ridges bordering the bituminous coal basins of Somerset and Cambria counties, and which extend thence into Maryland and Virginia.

Formations XII, and XIII. will be described when treating of the geology of Broad Top mountain.

Physical features of the Region.

Commencing with the knob of Terrace mountain, which terminates the synclinal valley, in a remarkably symetrical mountain, jutting boldly forward to the margin of the Juniata, the encircling belt of mountains here divides, and forms on the north-west Terrace mountain proper, and on the south-east Sideling hill enclosing an elevated basin-formed valley of the red shale, sloping with remarkable regularity from this extremity toward the base of Broad Top. Sideling hill running east of Chilcoatstown, bounds Well's valley on the east, while Wray's hill rising at De Forest's, three miles from Chilcoatstown, bounds the same valley on the west. After extending south some miles, this latter ridge curves rapidly backwards for some distance, when it again resumes its south-west direction, until it unites with Broad Top, to enclose the coal region. Opposite the curve, Harbour mountain commences, consisting of the sandstone F. V., elevated by an anticlinal axis. It separates Well's valley from another valley of the red shale F. XI., lying west of it, known as Ground Hog valley. Harbour mountain, dividing into two ridges, the eastern one curves eastward and unites with Sideling hill, thus shutting in Well's valley; the western one bending elliptically round the coal region to join Terrace mountain. This last named ridge ranges about south-west; tracing it along Trough creek valley, its south-east side slopes less and less until within eight miles of Savage's furnace, where the ascent from the valley to the summit is not more than five or seven degrees. There is a remarkable projection in the mountain on the south-west side of Norris's notch: that section of the ridge being heaved to the west. Something of the same feature is perceptible at Trough creek gap, to which points the axes disturbing the coal basin, are distinctly traceable. The mountain from Trough creek gap to its junction at Harbour or Cross mountain, is extremely regular. The interval between the two ridges, is occupied by Broad Top mountain and its coal basin, the topographical features of which we shall now briefly sketch. In order to do this intelligibly, we must trace the position of its axes of elevation.

BROAD TOP MOUNTAIN.—*F. XII., and Coal Measures.*

The north-east extremity of the coal basin terminates in a series of spurs, formed by several anticlinal and synclinal axes. The portion of the coal field lying towards the south-west, not having been yet explored by us, we cannot trace with precision the prolongation of these axes, in that direction. Broad Top mountain throws out no less than four spurs into Plank Cabin and Trough creek vallies. The first, and most eastern of these, is *Shirley's knob*, or its continuation: the second is *Round knob*, one of the highest: the third is called *Broad Top*: and the fourth lying nearest Terrace mountain, has no distinctive name, but Broad Top. Another knob called Round Top, rising directly at the furnace, is situated apparently in a line between the last mentioned spurs. Shirley's knob, and its continuation, is of synclinal structure, and this axis prolonged north-eastward, is the axis of Trough creek valley. South-westward it passes through the centre of Rocky ridge, which is composed of two ridges, or at all events, may be described as having two summits, between which lies Savage's coal seam, the lowest bed in the series. After passing through Rocky ridge, which, properly speaking, terminates two or three miles south-west of Savage's coal mine, in a high conspicuous knob; this trough, or synclinal axis, crosses the little valley of F. XI., near Mr. Samuel M'Lean's, and enters the knob *there* known as Broad Top, beyond which we have not pursued it. The next spur or knob, called Round knob, from its nearly circular, level summit, constitutes the second lesser basin, formed by the synclinal axis, which, leaving it, enters another knob opposite to it, called Grave mountain, from whence it ranges through the coal region. The anticlinal axis interposed between these two synclinal ones, passes between Rocky ridge and Round knob, crosses the little valley near M'Lean's, and extends thence between Broad Top and Grave mountains, while in the opposite direction, it can scarcely be traced to Trough creek.

The third spur, otherwise called Broad Top, contains the third synclinal axis, giving it therefore a basin-like structure. The second anticlinal axis, included between this last and Round knob, elevates F. XI. in Plank Cabin valley. The next spur towards the west, contains the fourth synclinal axis, which either enters Round Top at the furnace, or passes to the west of it, leaving it as a hill of elevation, thrown up by the third anticlinal axis, prolonged from between the third and fourth spurs. Most of these axes expire at Trough creek, thus spreading, in nearly horizontal position, the sandstone F. X. over a wide tract at the upper end of the valley, denominated the *Barrens*. Trough creek forms a natural boundary between this sandstone and the overlying red shale F. XI. Besides the axes already mentioned, there is a synclinal axis in Wray's hill, and an anticlinal axis between this and Rocky ridge. Wray's hill may be considered, geologically, as commencing at De Forest's, three miles south-west of Chilcoatstown, though it is continued by short and low knobs along the east flank of Rocky ridge and Shirley's knob. Further to the south-west, it acquires two summits under the title of Rocky ridge. The western ore widens beyond the end of Rocky ridge, and contains not only the synclinal axis, but an anticlinal one. Whether this latter traverses Wray's hill into the Harbour mountain is, at present, uncertain. Thus, at the north-east end of the coal region, we have in all, five basins in the strata, and four interposed anticlinal axes; an accurate knowledge of the position of which becomes of the utmost practical importance to develope the coal seams of this richly supplied region. These axes of elevation give to the surface of the general coal field of Broad Top an undulating outline, which has been rendered more irregular by the operation of great floods, cutting the flanks of this elevated table land into numerous deep ravines. The tangled thickets of laurel with which these are filled, and the fewness of good exposures of the strata, render the accurate exploration of this region a work of time and patience, and the late period of the season at which it was entered on, prevented our completing its investigation. Towards its south-west end, the structure of the region becomes somewhat easier to recognize, the exposures of the rocks furnishing more ample data. Another season, it is believed, will place us in possession of full information respecting the number, relative position, and range of the several coal seams and beds of iron ore, some details respecting which, I shall presently return to.

Directing our attention first to the resources of the surrounding red shale vallies, let us allude to the limestone and iron ore which belong to the bottom of F. XI.

Limestone.

A bed of greyish or clouded white limestone, occurs near the alternation of F. XI., and the subjacent sandstone. This rock is somewhat siliceous, and probably quite magnesian, burning with difficulty into lime. It is also slightly fœtid, and breaks, by exposure, into conchoidal fragments. In some localities it is purer, and has a smoother grain. This band of greyish limestone is from two to three feet thick. It has been opened on Little Trough creek, where it is nearly horizontal. Above this bed, lies a reddish limestone, about the same thickness, supporting a red shale, which is decidedly calcareous. These red and grey limestones are evidently equivalent to those which occupy a similar position in the series, west of the Allegheny mountain. A variety, having a finer grain, is found on Mr. Adam Lovel's farm. Here the rock is smooth, and has a cherty lustre; it makes a dark lime. The belt continues north, along the edge of the Barrens, through several farms; the layers being well exposed. Another belt should extend along the base of Sideling Hill, where hitherto it has not been sought for; the limestone following Little Trough creek to its junction with Big Trough creek, ranges near to this stream through Plank Cabin valley. A short distance from the furnace it is again quarried, is about three feet thick, and overlaid by calcareous red shale; it has been employed as a flux in the Trough Creek furnace. This belt should range through Little valley, between Terrace Mountain and Broad Top, near the base of the former. It is exposed on the road to Stonestown; it is visible at several points in Well's valley.

Iron Ore.

There is a massive variety of iron ore, which has been opened to some extent, near the Trough Creek furnace, and also in the vicinity of Hopewell furnace; it occupies a position at the very base of the red shale, at its contact with the underlying sandstone of F. X. Occurring in the gently inclined plane at the base of the mountain, this seam of ore might be naturally supposed to result from the percolation of water through the ferruginous sandstone of the mountain, but we hesitate in adopting this conclusion, when we reflect on the position of the ore at Hopewell furnace, where it appears to exist as a regularly interstratified bed between the rocks, much in the same manner as we find the fossiliferous ore in F. V. The excavations attached to Trough Creek furnace, are situated at the base of Terrace mountain, about one mile from the forge. The ore lies in lumps closely bedded together, suggesting, by the regularity of their position, and by the absence of much interposed earth, that they belong to the outcrop of a continuous bed. It exists in about five different varieties, several of which are very compact forms of the ordinary brown iron ore. When smelted by itself, it is stated to produce a highly coldshort metal. The analyses to be found in chapter VI., will exhibit its chemical nature.

The same ore is opened near *Hopewell furnace*, on both sides of the gap in Terrace mountain. The excavations on the north-east, are open to the day, but on the south-west side of the gap, the ore has been reached by a regular tunnel, ninety yards in length, intercepting the vein ninety feet below its outcrop, on the slope on the mountain. An air shaft extending up the vein, from the tunnel to the surface, exposes it, varying in thickness from twenty inches to three feet. Galleries or drifts have been made in both directions from the tunnel, but the seam of ore diminishes in thickness, and threatens to thin out. A shaft has been subsequently sunk, reaching the vein at a point forty feet below the level of the tunnel, where it retains the same thickness as above. It lies immediately at the contact of the sandstone with F. XI. It is interstratified with more or less clay. The ore here is of three kinds, the most abundant being brown, brittle, and of a smooth jaspery fracture, resembling closely one of the varieties at Trough creek. This species is said to make good iron, and to yield fifty per cent., which certainly seems to be a large amount. The second variety is of a more yellow aspect and slaty structure. The ore in the open diggings, on the opposite side of the gap, occurs also between the sandstone and red shale. The contour of the hill side, at this place, is such as not to imply an origin from infiltration; the ore appearing rather to be the outcrop of a regular vein. The adjoining red shale occurs in thick layers, which are soft and friable, and sometimes of a bright red hue, immediately contiguous to the ore. Near the margin of the deposite, thin layers of a sandy ore are interstratified with the red siliceous shale or sandstone, and approaching the vein, the red shale is disintegrated, passing to a sandy clay. Towards the middle of the deposite, the ore is both sandy and argillaceous. The principal mine is about 100 yards in length, and open to the day. The coarse yellowish white sandstone, F. X., forms one side of the deposite from which the ore has been removed. This bright red clay included among the ore, answers as a substitute for paint.

Iron Ore between F. XI. and F. XII.

In the alternating beds at the junction of F. XI. and F. XII., we meet with fragments of ore of a light chesnut brown color, similar to one of the varieties found in F. V. It would seem to be neither rich nor abundant. This ore is visible at the north-east end of Wray's hill, which is composed of these alternating rocks; and it occurs also in several other positions, easily traced by attending to the stratification, and the range of the axes previously mentioned.

Broad Top Coal Region.

The sandstone, F. XII., which immediately underlies the coal measures of Broad Top, possesses little of the conglomerate character which distinguishes it where it borders most of the other coal fields of the State, both in the anthracite and bituminous regions. It is hence not readily distinguished, in all cases, from some of the sandstones included between the coal, though a careful observer will find but little difficulty. The overlying coal measures appear not to be extensively developed, until we reach the central and south-western portions of the basin. After devoting a general, but tolerably minute examination, to be renewed hereafter, to the several spurs projecting into Plank Cabin valley, we have reached the conclusion that none of these synclinal axes, but Rocky ridge, contains any coal. The seam in Rocky ridge terminates about one-fourth of a mile south-west of the gap at Trough creek, the sandstones of F. XII. occupying, afterwards, the whole summit. It does not apparently prolong itself into Shirley's knob, the peculiar form of which seems to preclude its existence there. The sandstone, F. XII., occupies this hill from the creek to the summit of the knob. We shall allude in another place to the range of the coal seam through Rocky ridge. As the red shale, F. XI., extends far up the flank of Round knob, there is but little possibility of a coal seam in this spur; and the occurrence of the same stratum, nearly on the summit of the Grave mountain, in the same bearing as Round knob, is a further corroboration of this opinion. For a similar reason, the existence of a coal seam in either of the other two spurs of Broad Top, which extends into Plank Cabin valley, is somewhat doubtful; but this point will be definitely settled during the coming season. On Round Top, near the furnace, no bed of workable coal, we conceive, can occur. The alternating beds at the passage of F. XI. into F. XII., may be observed in a knoll on Trough creek, opposite to De Forest's, which is a continuation of Wray's hill. These consist of yellowish and greenish sandstones, red shales, and again of layers of a fine grained, very argillaceous green sandstone, making admirable whetstones; these beds indeed furnish whetstones in many places surrounding the coal region. Underlying the coal seam at Savage's mine, there is a stratum prominently exposed on the west side of the ridge, of a hard and massive, but fine grained white sandstone, speckled with mica. The angular fragments of this rock enable us easily to trace it through Rocky ridge. It is again seen a mile and a-half south of Savage's mine, on the eastern ridge, supported by a brownish grey sandstone. Below the latter are massive beds of a white sandstone, composed of granular milky quartz. Pursuing F. XII. along Rocky ridge, the upper sandstone maintains its character, while the lower bed becomes coarse—containing grained white quartz pebbels of the size of a grain of pepper, showing thus an approximation to the conglomerate type of the formation.

Where Trough creek rushes between Rocky ridge and Wray's hill, two and a-half miles south-west of De Forest's, is a high escarpment of sandstone, called the *Raven Rock*. The best exposed strata here underlie all of those above described, and consist of grey, whitish, and brownish hard sandstones, generally coarse grained, including occasionally thin layers of black carbonaceous shale containing vegetable impressions.

The Coal Seam in Rocky Ridge, has been opened adjacent to the western summit, about three-fourths of a mile S. W. of the gap occupied by Trough Creek. The coal dips at the mine sometimes towards the south, though more frequently south twenty-five degrees east, at an average angle of twelve or fourteen degrees. It is about four feet thick, is of excellent quality, and convertible into a good coke. Numerous oblique transverse joints divide it into rhomboidal fragments. The seam is overlaid, and also supported by solid layers of dark fine clay, each about six inches thick, which by exposure are converted into a plastic clay.

Another mine has been opened in the same range, about one and a half miles south-west of Mr. Savage's, where the coal bed is stated to be four feet thick. The excavation has become obliterated. The seam probably exists at intervals from this point, nearly to the end of Rocky Ridge, though it is not easily traceable. Indications of it occur above the Raven Rock, rather north of the high knob which terminates Rocky Ridge.

Wray's Hill.—For several miles the summit of Wray's Hill consists of the alternating beds of F. XI. and F. XII. Mr. Stumbaugh's coal diggings, lie about three-fourths of a mile north-east of Deever's and extend from near the summit of the west ridge to the ravine between the two summits. The coal seam at this place has an insufficient covering which renders it soft; it is also slaty. Its position is somewhat singular, the alternating beds of F. XI. and F. XII. occurring not more than two hundred yards west of the highest opening. The dip of the intervening strata appears not to exceed twenty-five degrees, making the extreme thickness of F. XII. not more than two hundred feet, which accords well with the observations made at other places. The rocks adjoining the coal, are different, however, from those near Mr. Savage's mine. At the upper opening, near the west summit, the strata dip twenty degrees to south seventy-five degrees east, and in the level space between the summits they are nearly horizontal, beyond which they dip slightly to the west. The alternating beds of F. XI. and F. XII. occupying the western summit, are traversed by an anticlinal axis, which causes this summit, in its range to the south-west, to become a broad and level hill, called *the Barrens*, which is opposite Deever's; it is nearly a mile in width. In this quarter the only coal seam on the hill is M'Lean's, opened two miles from Deever's. The surface rises into a circular knoll from the general level of the barrens, and around the brow of this upper hill is the outcrop of the coal seam. The excavation here having become obliterated, the thickness of the coal could not be measured, but it is stated to be four feet, the bed being separated by three inches of slate into two portions. It rests on slate and is overlaid by sandstone. It is said to be a light inflammable coal, readily consumed.

Houck's coal diggings occur two miles from M'Lean's mine, in a W. N. W. direction near Trough creek, where it separates Wray's Hill from Broad Top. The dip of the bed is about six degrees, and the difference of level between M'Lean's and this opening, is very trivial. The coal occurs in two benches, the lower varying from one to two feet in thickness, and the upper from one foot to one and a-half feet, the intervening slate exceeding, generally, one foot. The seam is overlaid by slate, containing some layers of sandstone. The coal contains more sulphuret of iron and is more slaty than that at Mr. Savage's mine. Its identity with M'Lean's bed, has not yet been positively ascertained.

A seam of coal, called Cook's vein, has been opened near the margin of a brook on Broad Top. It comprises four separate bands of coal; the first, varying from twelve to sixteen inches, is a little sulphurous and slaty, and is overlaid by four or five inches of slate; the second is five inches thick, much lighter than the rest, and overlaid by sixteen or twenty inches of slate; the third is an excellent coal; two feet in thickness, covered by three inches of slate, and the fourth, or uppermost, is about ten inches thick, overlaid by about three feet of slate supporting dark grey sandstone with vegetable impressions. The dip at this spot is variable, as it also is between this opening and Mr. Phillip Barnett's on the creek. Whether these two belong to one bed, or constitute two independent streams, a future season must decide.

At Barnett's opening, the bottom slate is very compact, and contains some sulphuret of iron. The lowest band of coal is twelve inches thick, and is used by the blacksmiths. Resting upon this, a slate occurs, five inches thick, and over this a superior coal, two feet ten inches in thickness, one of the purest on Broad Top. Above the coal lies a compact olive slate, which, if procurable in pieces of propers shape and size, would make a tolerable writing slate. Near the coal bed occurs some *nodular iron ore.*

Coal has also been found near Mr. Henry Horton's. There appear to be two seams on the farm of Mr. Henry Miller, and likewise on that of Mr. George Houpt, on the opposite side of a deep ravine. At the latter spot, the lowest, measures between two and three feet in thickness. Coal also occurs on the farm of Mr. Christian Barnett, one mile from Phillip's, where it also exists.

Towards the south-west end of the basin, occurs the *Riddle mine*, situated on Six Mile run, emptying into the Juniata, two miles below Hopewell. This appears to be the thickest seam of the Broad Top basin. For a considerable distance in from the mouth of the drift, it measures about five feet, swelling in some places to from ten to twelve feet. The roof is regular but the underlying slate is very uneven, sometimes rising rapidly and encroaching on the coal which is harder and less bituminous than much of the other coal in the region. This bed is not divided by any thick layer of slate, but little bands, only a fraction of an inch in breadth, often adhere tenaciously to it. Though the above opening is the most western on Broad Top, it seems doubtful whether it can belong to the lowest seam, for, were it so, the underlying sandstone F. XII. must exist here in far greater thickness than we have reason to suppose it does. At some distance from the mine the bed ultimately rises to the east, cropping out in the ravine which separates the hill in which it lies, from another further eastward. This latter hill, containing an anticlinal axis, the coal has been swept from it by denundation. The same bed should crop out on the east side of this hill, and accordingly we find on the road to Tigard's mill, a black slate connected with this coal seam.

On the creek between the second hill and Tigard's mill, another small seam about eighteen inches thick is said to show itself, there are several openings along Six Mile run, besides those above mentioned, but want of time has hitherto prevented their being examined. A section carefully measured along this stream would prove a valuable guide in determining the number and relative position of the coal seams of the basin.

Coal has been opened on the farm of Mr. James Tigard, a mile and a-half from the hill. It dips south, and is said to be two and a-half feet thick. About two miles from the mill, another excavation on the land of Messrs. Lloyd and Patterson, occurs in coal said to be five feet thick, dipping to the south; and another is to be seen at Mr. Richard Foster's, three and a-fourth miles from the mill, where the bed is two feet thick.

Near Trout run, about three and a-half miles from Hopewell furnace, occurs a valuable seam of coal, dipping seven degrees to the W. N. W. but becoming more inclined as we recede from the outcrop. In the main drift of the mine this bed is upwards of five feet thick and increases to seven and even eight feet. The overlying slate is hard and heavy and like that of the bed at the Riddle mine. The two coals also resemble each other, and belong probably to one seam, though they occupy different positions with regard to the axis of elevation. Like nearly every other bed of bituminous coal, it contains thin laminæ of slate, and a little sulphuret of iron. Between the above large vein and Hopewell furnace there is another, appearing about a mile and a-quarter further west, which is eighteen inches thick. This is probably that which overlies the Riddle bed, and if so, the principal seam should be found at a lower level in the small ravine of the mountain. One point is clear, that the seam at present worked for the supply of Hopewell furnace, should crop out at least in three different places nearer the furnace than where the mines are now established. This information was imparted to the manager of the furnace.

SECTION V.

District between Tussey's mountain and the Allegheny mountain.

The next belt of country embraced in the investigations of the past year, in the portion of the State before us, comprehends the interesting chain of vallies lying between Tussey's mountain and the base of the Allegheny. The exploration commenced in the neighborhood of Pine Grove, west of the termination of Stone valley, and extended to the southern end of Morrison's cove, the close of the season arresting our further progress. The north-eastern extension of this belt through Centre county, was examined in much detail during the previous summer.

Commencing our present brief account of the formations, with a sketch of Tussey's mountain, we shall trace this ridge from Pinegrove to the Raystown branch. Between Pinegrove and the Little Juniata river, the structure of the mountain is rather uniform. The white sandstone, the upper of the three divisions of F. IV., forms a nearly straight, occasionally undulating summit, in which the depressions are few and not deep. A terrace or bench occupies its north-west slope, a considerable distance below this crest, intersected as usual, at intervals averaging about three-fourths of a mile, by deep ravines, or short vallies of denudation. In some places, the terrace nearly rivals the principal summit in height. Approaching the river it becomes more depressed, the ravines more numerous, and the northern slope of the mountain more abrupt. Still nearer the Juniata, the proofs of violent denudation by water are still more striking, the margin of the terrace appearing sometimes as a bold escapement of the lower grey sandstone of F. IV. That section of the ridge, included between the Little Juniata and the main river, called Short mountain, present a regular summit; but the denudation has been such as to leave scarcely any terrace. From the Frankstown branch south-west for a few miles, the mountain does not reach its usual elevation. The river here has its course in the soft red argillaceous rocks, composing the middle division of the formation, leaving the lower sandstone in a small, sharp, isolated ridge of the shape of a colossal grave. This is about two miles long, the river intersecting the lower sandstone by a gap above which it flows in the slate F. III., and the limestone F. II. of Canoe valley.

About five miles from Alexandria, the whole mountain exhibits a remarkable displacement in its course, forming a flexure like the letter S, caused by the folding round of the formation over a short anticlined axis, which runs obliquely from the main axis of elevation of the valley. South-west of this curve it pursues a regular course, with some trivial inequalities, to Yellow Creek, ranging about south thirty degrees west, while its direction north-east of the Little Juniata, is about south seventy degrees west. Approaching Yellow Creek, there are several unimportant notches in the main summit of the ridge, but no true gap exists until we advance within a few miles of another double flexure of the mountain near Yellow Creek. North-east of this stream occurs a flexure simiiar to the former, produced by the termination of an anticlinal axis deflecting the mountain for a space out of its regular course. This axis of elevation is continuous with that which produces a corresponding flexure in the Muncy mountain, enclosing Brush Valley. From the neighborhood of Yellow Creek, the mountain becomes higher, more regular, and exhibits less waste from violent floods, the terrace rising to a great elevation.

At the gap of Yellow Creek, the strata dip forty degrees to south seventy-five degrees east. From this point to the gap at Raystown Branch, the formation is uninterrupted, presenting merely a slight deviation in its course near the termination of Morrison's Cove, curving a little more towards the meridian, where it forms the east side of Snake Spring Valley.

The slate F. III. ranging at the base of Tussey's mountain, skirts the eastern side of the Great Limestone Valley, throughout its entire length, maintaining great uniformity in its aspect and structure. At the contact of this rock with the overlying sandstone of F. IV., we perceive layers of black and dusky olive slate, alternating with dark argillaceous sandstones. Approaching its inferior limit, the slate begins to alternate with dark argillaceous limestones; these calcareous bands, increasing in number and thickness as those of the slate, progressively diminish.

Along no portion of the belt does the slate appear as a very thick stratum, its maximum depth probably not exceeding six hundred feet. It generally composes the lowest part of the aclivity of the mountain, sometimes extending nearly to the verge of the terrace on its side when the denuding action has been relatively feeble. At Lower Colerain Forge, near the Little Juniata, it gives proof of considerable waste by floods, Spruce Creek having its channel in this slate, sweeping the foot of the terrace, while the dark grey sandstone, the lower division of F. IV. rises from the stream in a tall escarpment or wall. At the folding round of Tussey's mountain opposite Williamsburg, the slate is embraced in the recess, forming two short hills jutting forward at right angles from the main ridge.

Limestone F. II.

The anticlinal axis of Brush valley, elevating to the surface, the limestone F. II., near the head of that remarkable nook, terminates in Morrison's Cove, south-west of Martinsburg.

The country between Tussey's mountain and the first range of barrens, traversing the central part of the main limestone valley, north-east of the Juniata, is a gently undulating surface, along which the limestone is elevated by an anticlinal axis, prolonged from Penn's Valley. The banks of Spruce creek, exhibit occasionally fine exposures of the strata, forming the south-east side of this axis, while Warrior Mark run intersects it diagonally. The little Juniata itself exhibits a section of this part of the belt, showing satisfactorily the true position of the axis. The rocks on the south-east side of the line of elevation, dip to the south-east at an angle of about forty degrees, while the inclination of those on the opposite side, to the north-west, is somewhat steeper. A section a few miles further to the south-west, displays a change in the position of the strata. Crossing their outcrop from the end of Cove mountain to Tussey's mountain, the rocks on the north-west side of the axis are nearly vertical, while those south-east of it, though sometimes steep, have generally a less inclination. The line of elevation in the limestone, takes here a course more towards the south. The belt of the valley between the two mountains is elevated, and the slate spreads to a considerable distance from the base of canoe Mountain. The valley sometimes called Canoe valley, is traversed south-westward by the axis, preserving the same nearly vertical attitude, in the strata along its north-west side. The Juniata river, after crossing the valley at Williamsburg, winds along the south-east side of this axis, sweeping sometimes the base of the mountain in the slate of F. III., sometimes cutting through the limestone almost to its line of elevation. The only interruption which this anticlinal line presents, is when it sends off the short axis of elevation, which causes the flexture in the mountain south-east of Williamsburg. Beyond this point, to the other similar bend in the mountain, at Yellow creek, opposite which the axis terminates, it is remarkably regular. This axis, which we have been tracing, terminates in the little sharp cove, south-west of Martinsburg.

In the wide limestone valley, embraced between Tussey's mountain and the Bald Eagle or Muncy mountain, we have two parallel anticlinal axes; that on the south-east being the same which elevates the rocks in Brush and Penn's valleys, and that on the north-west, the prolongation of the axis of Nittany valley, the included trough or synclinal axis, being the same which contains the Nittany mountain. About ten miles south-west from Bellefonte, the Nittany valley axis loses its symetrical structure; the strata lying north-west of it becoming vertical, and soon afterwards *inverted*, ranging in this attitude through Halfmoon and Warrior Mark vallies, into Sinking valley, five miles south-west of the Little Juniata. Here the rocks resume their more natural posture, dipping to the north-west until the axis terminates south of Hollidaysburg.

The trough or synclinal axis of Nittany and Canoe mountains, is occupied by an extensive range of sandy barrens, which stretches almost uninterruptedly from the bed of the one mountain, to the commencement of the other. Along this line there are few exposures of the strata. In this belt occur the chief deposites of brown *iron ore*, for which this valley is remarkable. There would appear to be, however, no strict rule of uniformity as respects their position. A fertile tract, in which the limestone shows itself, borders this range of barrens on both sides, extending to the foot of the bounding mountains. That on the north west forms the vallies of Half Moon and Warrior Mark, while Spruce Creek valley forms the belt on the south-east. The barrens themselves consist of broken and undulating hills, separating in some places into two ranges, corresponding to the two anticlinal axes of the district, enclosing numerous hills of sand and clay, between which we occasionally meet with exposures of the lower beds of the limestone. These intervening lower hills present no uniformity. In some places the barrens embrace four ranges of hills, and in some places three. The relation of these hills to the enormous deposits of iron ore near them and among them, is as varied as their topography, though something like system is observable; thus on the north-west side of the broad synclinal axis, there is a long chain of ore banks, extending from near Bellefonte to the Little Juniata, not departing far from the line of the Nittany valley axis. The ore beds lie usually on the range of sandy hills, on their south-eastern slopes, and near their summits, though sometimes they occur on their very tops, and again on their sides facing the north-west. The hollows between these hills also contain, occasionally, rich accumulations. These are the positions of the large ore banks of Julian, Curtin's, Hannah, Bald Eagle and Huntingdon furnaces. The south-eastern anticlinal axis presents us with but one group of ore banks, namely: those attached to Pennsylvania furnace, but there are a number of other excavations in the intermediate space between the two ranges.

All the ore of this belt of country belongs to one general species, the brown or *hematitic iron* of mineralogists; it exhibits, however, an almost endless variety of structure and much diversity of composition. Some of it is earthy and compact, approaching the jaspery iron ore; some of it highly porous and cellular; some regularly stalactitic, receiving the name of *pipe ore*, while other portions occur in hollow geodes, often lined with the crystalline hematite, and occasionally filled with water. The imbedding earth is itself no less various, consisting of clays and sand of nearly every hue: brown, yellow, red and other tints, derived from the oxide of iron. The lumps of ore are lodged in these deposites in almost every conceivable manner; sometimes in isolated pieces in the clays, sometimes, in narrow layers called veins, sometimes grouped into bunches, and sometimes forming vast blocks, weighing each several tons. The chemical composition of these ores, will be specially alluded to in the final chapter of the present report, where mention will be made of our iron ores generally.

The only indication to be relied upon in seeking for the ore, is the relative abundance of its fragments upon the surface.

The Slates of F. III.

The slate ranging along the north-west side of this belt of limestone vallies displays the same features already noticed, as characterising it at the foot of Tussey's mountain.

The Sandstone Rocks of F. IV.

These form Bald Eagle, Brush, Canoe, Lock, and Dunning mountains bounding this chain of limestone vallies on the north-west and west. At Milesburg, in Centre county, the strata dip steeply to the north west, their angle being nearly seventy five degrees. From this point south-west for some miles, the crest of Bald Eagle mountain, is high and undulating, its south-east flank containing the usual terrace. About eight miles from Bellefonte, its features change in conformity with the abrupt overturn of the rocks near the anticlinal axis. The crest and terrace of the mountain become depressed, and more irregular in their outline. The Slate F. III., rising to the verge of the terrace, and sometimes even forming a part of it, while this shelf is more frequently cut by deep ravines. These are quite conspicuous near Hannah and Bald Eagle furnaces. The Little Juniata river affords a good display of the rocks of F. IV, in this mountain, which ranges with little deviation to a point about five miles south-west of the river. It then undergoes a remarkable alteration in its outline, the crest rising suddenly to a conspicuous height above the low, denuded terrace. A corresponding change in the attitude of the strata, explains this new feature. The rocks north-west of the axis, which for a previous distance of several miles, are inverted or overturned in their dip, here assume a less disturbed position, inclining regularly to the north-west, the massive sandstones of the mountain involved in the same derangement, assuming also their natural attitude. Throughout that part of their course, where they stand nearly vertical, or have been crushed more or less by the invertion, they have opposed a less resisting barrier to the tremendous energy of the denuding waters, which have shaped the vallies and mountain ridges of our State. Where the rocks change their posture and take a gentler dip, they presented a broader bulwark to the floods, and have, therefore, undergone a less extensive devastation. From this point to Hollidaysburg, where the great sandstone formation folds over the expiring axis of Nittany valley, the mountain preserves great uniformity of structure, its crest being high and regular, and the terrace broken as usual at given intervals by deep ravines. A slight change in the direction of the mountain, occurs a short distance north of Black's gap, opposite to which the main limestone valley terminates in a little trough shaped one, about two miles in length, produced by the scoping out by the waters escaping through this notch, of the soft middle strata of F. IV., the denundation of which usually causes only a flat shelf or terrace.

The sandstone belt F. IV., sweeping round the end of the axis in a broad knob, north of Hollidaysburg, assumes a north-east direction to form the north-west boundary of Scotch valley. At the head of this, falling into the synclinal trough, prolonged from Nittany valley, it curves suddenly back to the south-west, making the end of Canoe mountain, where it displays a prominent synclinal knob, flanked on each side like those in Kishicoquillas valley, by a broad terrace of the middle beds of the formation. From this end of Canoe mountain, the formation ranges in a regular ridge for about five miles. The Slate F. III., occupying every where its usual position at the base of the ridge. Opposite Etna furnace, the mountain exhibits a sudden and remarkable change in its strata, which are heaved by a dislocation, much to the west of their previous range, and at the same time inverted, presenting a broad irregular bulge at the commencement of the overturn. This fracture in the rocks gives rise to a very complicated structure from this point to the gap at the Juniata, a description of which could not be rendered intelligible without the aid of a map and sections. Short mountain or Canoe hill, is the regular prolongation of Lock mountain, separated from it only by the gorge at the river. From this point to the end of Lock mountain, where it folds under the synclinal axis, north of Martinsburg, the formation is regular, dipping steeply to the north-west, the upper division forming the high sharp crest of the ridge and the lower, the margin of a well defined terrace.

Curving as it passes the synclinal axis, the whole formation folds back towards the north-east, to double once more towards the south in the broad and high knob, south of Frankstown, where it folds over the anticlinal axis, which ranges from this point through Brush valley, as already described. From this point, it pursues a nearly southern course, under the name of Dunning's mountain, showing conspicuously the effects of denuding action, until it curves again at the head of the valley called Dutch Corner. The low and broken double crest of the mountain throughout this part of its range, is the result of a vertical upheaving of the rocks, and their consequent shattered condition, by which, as in the instance of the Bald Eagle mountain, the strata have been more readily affected by denuding currents than elsewhere. At the curve of the mountain at Dutch Corner, its features change; instead of presenting a double chain of knobs, one formed by the upper, the other by the lower, sandstone belts of the formation, the whole stratum doubles over a short anticlinal axis, which diverges from the centre of the valley, imparting greater height and regularity to the summit. After making a double flexure round this axis, and round the head of the synclinal basin in Dutch Corner, the mountain resumes once more a S. S. W. direction. At the most eastern part of the bend, the lower strata of the formation coalesce with the corresponding ones in Tussey's mountain opposite, thus closing up the lower end of Morrison's Cove, leaving only a narrow rugged passage between it and the next, or Snake Spring valley on the south. The mountains soon separate, the same anticlinal axis elevating the limestone in the southern part of Morrison's Cove, and lifting this rock to the surface in the adjoining valley just mentioned.

From the end of Lock mountain to the synclinal axis S. E. of Woodbury, which is a prolongation of that passing through the knob of Lock mountain, Morrison's Cove embraces two lines of elevation, and one of depression, in the strata. The axis of Snake Spring Valley, commences at Frankstown, and passing through the knob just south of it and through Brush valley, traverses the Cove, and enters Snake Spring Valley by the pass above described. The rocks on the east of this line dip east twenty-five degrees, while those on the west dip forty-five degrees to the west, and are in some places vertical.

Iron Ores.—Near the line of this axis we have a belt of barrens, composed of superficial sand and clay with iron ore, similar to that noticed in the same limestone range further to the north-east. The denudation in Morrison's Cove, having been less than in the other part of the belt, the deposites of clay and sand occupy a wider zone along its centre. Connected with Sarah and Woodbury furnaces, there are many extensive excavations for iron ore; but want of space will not permit me to describe these and the other interesting mines of this belt in detail, or do more than present a brief sketch, together with some analyses of the characteristic varieties of the ore. The ore belongs to the brown hematitic species, common in the limestone vallies, its two predominant varieties being the compact brown ore, either in large masses, or minute fragments, and a massive cellular ore of a somewhat lighter tint. Another belt of ore deposites, occupying the other anticlinal axis of the cove, presents a greater diversity of forms.

Springfield furnace has around it several ore banks which furnish a great variety: one yielding a large supply of rich ore mingled with much sulphuret of iron; another affording a dark variety, in great abundance, containing much oxide of manganese, while another bank supplies a hard and siliceous lump ore. But besides these kinds there is an immense quantity of ore of superior quality.

The ore banks of Rebecca furnace, produce also, many sorts. One furnishing in part *pipe-ore* of the richest kind; another a compact hematite in large lumps and hollow nodules of every size and form; and another, an ore so sulphurous as to be unfit for the furnace. The analyses in chapter VII., will exhibit the usual composition of the better kinds of ore found so abundantly along this central belt in Morrison's Cove.

Snake Spring Valley, is but the northern termination of a long and rather regular valley of elevation, which south of the Raystown Branch of the Juniata, takes the name of Friend's Cove. It consists centrally, of the limestone F. II. bounded on each side by the overlying slate, ranging at the foot of Tussey's mountain on the east, and Dunning's or Evitt's mountain on the west. From the head of Snake Spring Valley, it is traversed by an anticlinal axis, on the western side of which, the limestone is sometimes nearly vertical, and is every where steeper than on the eastern. This cove or valley, has not yet been explored in detail.

Of the Valley at the base of the Allegheny Mountain.

Red and Variegated Shales, F. V.

The north-west flank of Bald Eagle mountain being generally covered throughout its lower half by a deep deposite of debris, washed from the adjoining ridges, the shales of F. V. are visible in but few exposures from Milesburg, to the Juniata river. This formation has been penetrated at a number of points in pursuit of tho fossiliferous iron ore which belongs to its middle strata, and though some of the calcareous layers have been found slightly impregnated with oxide of iron, the true fossiliferous ore has not been yet discovered. Several openings have been made at Julian and Hannah Furnaces. Here the shales occupy the slope of the mountain, and where the dip is vertical, extend sometimes to its summit. The lower, more gentle acclivity of the mountain, formed by the soft shale, is usually covered with oak; the higher and steeper slope caused by the sandstone F. IV. sustains more generally pines. This order of things prevails to the point where the vertical attitude of the rocks passes into a more gentle dip, accompanied by an increased altitude of the ridge, beginning about five miles north-east of Tyrone Gap. From this point the fossiliferous ore occupies its usual position in the stratum on the north-west slope of the mountain, at a short distance from its base, its outcrop being designated by a slight elevation. The ore varies from ten to sixteen inches in thickness. It is compact and moderately rich, and is associated with calcareous beds containing but little oxide of iron. Both the ore and the calcareous layers, are interstratified with beds of olive-colored slate, unaccompanied by any stratum of sandstone either above or below them, such as designates the ore in the Lewistown and Stone Vallies. Near Bell's furnace, the ore has been opened in several places. When mixed with the compact brown ores from the limestone belt on the south-east, a very superior iron is abundantly produced.

Formation V., attended by its belt of fossiliferous ore, maintains the same position near the foot of the mountain, until the rocks fold over the articlinal axis at Hollidaysburg. Here the inclination of the bed is very gentle. Hollidaysburg stands upon the feruginous layers, in the upper part of F. V., further south from the knob of the mountain than the outcrop of the genuine seam of ore. Near Frankstown, the fossiliferous ore is met with among the olive shades of F. V. associated with a few thin calcareous and ferrugiuous layers, and unaccompanied by any bed of sandstone of sensible thickness. The layer of ore at this place is fourteen inches thick, and near its outcrop is of very superior quality, containing but little calcareous matter. It is smelted in the Frankstown furnace by itself and affords a large proportion of iron. The mine is on the south slope of the mountain, and one mile north-east of of Frankstown.

Several exposures of a thin impure fossiliferous ore are visible in the town of Hollidaysburg; but these occur too high in the formation to be a part of the true ore bed. This ferruginous calcareous seam is associated, moreover, with a different group of rocks from those which imbed the true fossiliferous ore, as we may plainly behold, in a fine section of the strata on the Portage railroad, three-fourths of a mile above the town. At this place we witness a number of the same feruginous calcareous seams, from one to eight inches thick, interstratified with variously colored shales, sometimes several feet in thickness, and with still thicker beds of sandstone. Some of this fossiliferous material is moderately rich in iron, while other portions are hard and superabound in calcareous matter. After doubling over the anticlinal axis at Hollidaysburg, the ore bearing formation F. V., takes its course along the base of Brush Mountain, bordering Scotch Valley on the north-west. We have here the same condition of things as upon the north side of the axis, F. V. forming the base and lower slope of the mountain, and a low protuberance on the flank, marking the range of the fossiliferous ore. It is exposed in a number of places, though hitherto it has not been extensively opened.

The shales of F. V., folding round the end of Scotch Valley, here called the Beaver Dams, assume a south-west direction along Canoe mountain, ranging regularly as far as the dislocation north of Williamsburg, where the stratum becomes involved in the sudden inversion which affects all the rocks of the mountain, becoming concealed until the ridge terminates at the river, where the beds appear in the most contorted and disturbed position. Here a number of excavations have been made in quest of the fossiliferous ore, but the strata are so confused and crushed that it is not traceable for any distance, appearing to divide in some cases into several thin calcareous seams, slightly impregnated with iron. It is barely possible, however, that these represent not the true fossiliferous ore, but the ferruginous and calcareous layers found at Hollidaysburg. On the the north side of Canoe hill, the shales assuming their regular position, or a steep north-west inclination, the ore exists in a thin bed of porous structure, between six and eight inches thick, unaccompanied by any thick layer of sandstone. It has been opened for the adjoining furnace, but will not repay the cost of mining it.

The formation resting steeply on the flank of Lock mountain, rises high up on its north-west acclivity, and is thickly covered by fallen earth and fragments from the ridge. Ranging to the south-west, it curves round the loop or recess of Old Town run, following the recurving spur of the ridge with a gentle south-east dip. In this part of its course, the fossiliferous ore is embraced in the hills at the base of the mountain, being discoverable on the surface in numerous rich specimens. The bed itself was found exposed two and a-half miles from the head of the loop. The ore is good, though only seven inches thick. A thicker seam may exist, but such was not discovered. The ore bearing formation folds over the anticlinal axis in the Broad Knob, south of Frankstown, to follow Dunning's mountain, towards the south. This ridge having its strata vertical throughout a course of many miles, the shales, F. V., rise in this case as they usually do, high up upon its slope. At the gap, near Martha forge, they form a constituent part of the mountain, the limestone F. VI. and sandstone F. VII. lying at its base. As far south-west as Sarah furnace, the fossiliferous ore does not show itself on the surface, in consequence of this state of things, the only exposures of the strata being in M'Kee's gap at Martha forge. At this place, some of the upper shales adjacent to the limestone, are visible, but the fossiliferous ore cannot be detected by any indications on the surface, the portion of the stratum containing it being too much concealed.

Limestone F. VI., and Sandstone F. VII.

Ranging near the base of the Bald Eagle or Muncy mountain, and the ridges forming their continuation towards the south, the fossiliferous limestone and overlying sandstone usually form a more or less distinct ridge, which is sometimes, however, obliterated by denudation. The average thickness of the limestone is probably about two hundred feet, while the coarse sandstone that surmounts it, is usually not more than one-fourth of this thickness. From Milesburg to the Little Juniata, in consequence of the nearly vertical attitude of the strata, both of these formations are very obscurely exposed. They rest close under the base of the mountain, while the dark slates of F. VII. generally occupy the valley between them and the Allegheny mountain. At Julian furnace they do not appear on the surface; but from information imparted to the proprietor, respecting the position of the limestone, it has since been reached, thus saving him the necessity of procuring a flux from the other side of the mountain.—A range of *sink holes* at the base of the ridge generally indicates the position of this limestone. It forms, however, a short ridge at the foot of the mountain, a few miles south-west of Bald Eagle furnace, continuing, with occasional interruptions, nearly to M'Cammit's forge. A few massive beds of the overlying sandstone occupy the north-west slope of this ridge, beyond which, to the north west, commence the slate of hills of F. VIII. Where the river cuts the ridge, one mile south-west of Crotzer's forge, the whole thickness of the sandstone stratum is between sixty and seventy feet.

There is a change in the attitude of these two formations, corresponding to the altered posture of all the rocks, commencing at the rise in Brush mountain, five miles south-west of Tyrone gap; their previous steep inclination to the north-west, giving place to a gentle dip, succeeded further to the south-west by an anticlinal axis, occurring at some distance from the base of the mountain. The trough in the strata, between the mountain and this anticlinal axis, embraces a synclinal ridge of the sandstone F. VII., supporting the lower dark slates of F. VII., in the vicinity of Bell's ore bank. This synclinal axis, analagous in all respects to those previously described, as traversing the Lewistown valley, contains the valuable ore banks of Bell's and Allegheny furnaces, the ore existing apparently at the former, in precisely the same geological relations before adverted to, as marking its situation north of Waynesburg, at the head of the Juniata, in Little Cove, and elsewhere. The ore itself exhibits very nearly the same structure, being dark brown and cellular, the cavities sometimes empty, sometimes filled with clay, sometimes with a loose nucleus or enclosed lump of undecomposed blue protocarbonate of iron. That of Bell's bank is frequently siliceous, though it is productive and yields a good iron. The excavation occurs one mile from the north-west base of Brush mountain. The ore bank attached to the Allegheny furnace is in the same range, about four miles remote from the furnace. This is a much larger excavation than the former. The ore is of the same varieties, embracing, however, a greater proportion of the large cellular lumps. The deepest part of the digging exposes a yellowish, porous sandstone, near the contact of F. VI. and F. VII., with ore infiltered between its fissures. The clay deposites of this synclinal axis have been derived from the disintegration of this soft rock, which is much impregnated with iron. Near Allegheny furnace, another ore bed occurs in the clays of this trough. This consists almost entirely of *pipe-ore*, from which some large and beautiful stalactitic columns have been obtained. The ores of Allegheny furnace seem not to have been produced from the black slates at the base of F. VIII., but rather from the soft yellow ferruginous sandstone near the bottom of F. VII.

The valley between Brush and Allegheny mountains, exhibits some

change in its features, from where the anticlinal axis shows itself.—From M'Cammit's forge or Tyrone Gap, the valley expands by a change in the direction of both mountains, changing from a breadth of two or three miles to one of six or seven miles. It assumes very nearly the character which it has at its other end, near the Susquehanna. Pleasant valley and Logan or Tuckahoe valley, occupy a part of this broad interval. The anticlinal axis elevating F. IV. and F. VII., forms a range of hills or ridges, separated from the Brush mountain by a little valley, and from the slate hills to the north-west, by another; this axis does not extend south-west of Allegheny furnace. Beyond this, the mountains fold over the other or main anticlinal axis of the mountain, at Hollidaysburg, and displays a symetrical and beautiful feature in the topography.

From Allegheny furnace, the belt of hills composed of the limestone and overlying sandstone, after passing Duncanville, sweep in a regular curve south of Hollidaysburg, and take a direction along the south-east side of Brush mountain. Formation VI. is here in its middle beds a pure blue limestone, but partakes near its contact with F. V. and F. VII., of the aluminous character of the former, and the sandy nature of the latter. The limestone, together with the sandstone which it supports, preserve their position in a prominent ridge throughout their course along the north-west side of Scotch valley. About five miles from the river, near the head of this synclinal basin, these strata sweep round to pursue the base of Canoe mountain, in its course to the south-west. Like all the strata near them, they are implicated in the invertion or overturn of that ridge, which we have already more than once alluded to, and appear much contorted at the gap of the Juniata. This disturbed condition of things prevails for some distance along the western side of Lock mountain, until approaching the "loop" the formations become more regular, and curving round at the head of this synclinal basin, they range towards the knob south of Frankstown. Here, as in the case of F. IV., beneath them, they fold over the anticlnal axis, to pursue their course near the base of Dunning's mountain. These formations compose a regular chain of hills encircling the isolated tract of F. VIII., in the centre of this basin of Scotch valley and Old Town Run. The limestone along Lock mountain, is for some distance blended with the slope of the ridge; but where the nearly vertical dip is replaced by a gentle one, a short distance south-west of the river, then the limestone and overlying sandstone leave the foot of the mountain, and form, as usual, a ridge to themselves.

The anticlinal axis elevating the high knob south of Frankstown, overlapping or passing the anticlinal axis of Brush mountain, north of Hollidaysburg, the two form between them a small synclinal trough, in the sandstone F. VII., immediately at Frankstown, in the middle of which, occurs a shallow belt of F. VIII. This collapsed axis extends but two miles north-east of the town, terminating in a little contortion of the limestone, which soon disappears in the general south-east dip of that formation, in Turkey ridge, along the margin of Scotch valley.

In the little belt of slate referred to, should occur the band of iron ore characteristic of the lower part of that formation in other districts, but it is probable that the calcareous and ferruginous layers of the formation, have either been washed away, or did not enter originally as a part of the stratum. The fine grained argillaceous sandstone at the bottom of F. VII., to which we ascribe the ore banks of Allegheny furnace, appears in this neighborhood to be very thin, and almost vanishes as we proceed to the south-west.

Olive Slate F. VIII.

The belt of dark slate, together with the overlying rocks of F. IX. lying at the base of the Allegheny mountain, show a tract of gently rounded hills, divided by irregular ravines. Sometimes these hills form two ranges, separated by somewhat regular hollows; but these uniform features in the topography are not of great extent. The valley of the Bald Eagle creek, at Milesburg, formed by the floods escaping through the gap, is a level plane, for some distance, enclosed between these slate hills and the Bald Eagle mountain. Towards the south-west, the slate hills encroach, and leave but a narrow valley between them and the ridge. This occurs at Hannah furnace, two miles south-west of which, the slate hills lie at the very base of the mountain, in consequence, no doubt, of the vertical attitude of all the strata. Beyond this to the south-west, they again recede, leaving a little valley drained by the head waters of the Little Juniata. A section crossing the slate, and the overlying beds of F. IX., along Wallace's run, exhibits a dip of about forty degrees to the north-west. Further to the south-west, the inclination of the beds is occasionally steeper; but the uptilting of the strata which has brought the slate near the foot of the mountain, does not so much affect it as the other strata immediately south-east, which have passed into a nearly perpendicular attitude. Near Hannah furnace, ten miles from the gap of the Little Juniata, the hills of F. VIII. and F. IX. are higher and bolder than usual. They continue thus until south-west of Bald Eagle furnace, where they recede from the mountain, leaving Logan's valley between. They then become lower, and present gentler slopes. These features extend along Logan and Pleasant vallies, the formation still preserving a regular dip to the south-west, until the whole sweeps over the subsiding anticlinal axis of Brush mountain, four miles south-west of Hollidaysburg. Opposite Blair's gap, the rocks all dip at a moderate angle to the north-west. Near Newrey, we have an anticlinal elevation in the valley between Dunning's mountain and the Allegheny; leaving a trough in the rocks at the base of the former ridge, in the continuation of the synclinal axis of Frankstown. The black slate at the bottom of F. VIII., extends in a narrow belt along this trough to Frankstown, where it disappears.

As before stated, a large tract of F. VIII., occupies the middle of the basin of Scotch Valley and Old Town run. The highest beds of the formation left in the centre of this valley, are the grey sandstones and dark olive slates of the upper portion of the stratum.

From Newrey southwest, the formation resumes its regular W. N. W. dip, at an angle generally exceeding thirty degrees. The belt has not been yet traced further in that direction than Sarah furnace, in Bedford county. Minute and careful observations were made, with a view to detect the existence of a vein of iron ore analagous to that found in the lower portion of the stratum in Lewistown valley and Little Cove, but hitherto without success. The absence of a visible outcrop of the ore may arise, in part from the non appearance of the narrow trough-like ridges of the sandstone F. VII. which elsewhere sustains the belt of the ore, leaving part of the slate under circumstances well calculated to reveal the bed. The axes of elevation producing that peculiar feature in the topography, are here wanting.

Red Sandstone F. IX.

The red argillaceous sandstones and red slates constituting F. IX. form a belt of rounded and denuded hills, skirting the base of the Allegheny mountain; the whole south-eastern slope of which likewise embraces these rocks, which are only surmounted by the sandstone strata of F. X., near the summit of the ridge. This order of things prevails along the whole escarpment of the mountain, except in the neighborhood of the Blue Knob, the structure of which will be presently explained. From Milesburg for a considerable distance south-west, the hills composed of F. IX, are rather elevated and steep, but as we advance they subside, while the spurs jutting forward from the flank of the Allegheny become relatively more prominent. Approaching Hollidaysburg, the hills at the base of the mountain, consisting of F. VIII. and the lower rocks of F. IX., form a belt presenting regularly rounded and undulating slopes, evincing the enormous amount of denudation to which they have been exposed. The table land of the Allegheny mountain, lying beyond them to the north-west, shows in the same neighborhood, a great number of deep transverse vallies, or long ravines extending down its flank, which have obviously given passage to the retreating floods which scooped the great valley at its base. The promontaries or spurs embraced between these ravines, stand forward from the flank like enormous buttresses or ramparts.

The general dip of the strata at the base, or in the flank of the Allegheny mountain, is from fifteen to thirteen degrees towards the north-west, but at the Blue Knob this state of things is interrupted. An anticlinal axis, ranging immediately at the base of the Allegheny mountain, a portion of the strata south-east of this line, have a gentle dip to the south-east, meeting the north-western dipping beds of the valley between Blue Knob and Dunning's mountain, to form a synclinal trough under the Blue Knob itself. The strata of Blue Knob reposing thus in a basin have escaped the denudation which has removed the more exposed and crushed portion of the formation overlying the anticlinal axis; thus causing a valley between it and the mountain.

This structure extends as far as Bob's creek, where the flat anticlinal axis passing Blue knob begins to disappear.

Throughout the long belt here briefly sketched, Fs. VIII. and IX. exhibit great uniformity as respects their composition. The calcareous or cement beds so conspicuous in the lower part of F. VIII., along the valley of the Susquehanna as far as the mouth of Bald Eagle creek, diminish, and almost disappear when we pass to the south-west of Milesburg, and are represented by only a few dark calcareous bands containing sulphuret of iron, and occupying the black slates near the base of the stratum.

Much search was made with a view to discover if the curious red stratified ore which belongs to the lower part of F. IX., at Larry's creek and Pine creek, near the base of the Allegheny mountain, extends to the south-west, but every effort to trace it beyond the neighborhood of Farrandsville, has proved ineffectual.

CHAPTER IV.

Geology of the District north of the Allegheny Mountains, including Lycoming, Clinton, and Tioga counties.

In Tioga, Lycoming, and Clinton counties, our explorations were principally confined to the less inhabited sections lying north of the southern base of the Allegheny mountain. As far as the nature of country would permit, all the coal beds were examined, and their extent ascertained and delineated on the State map. The whole of the coal in this section of the State would seem to be confined to four narrow basins, traversing these northern counties in an E. N. E. and W. S. W. direction, parallel to the range of the Allegheny mountain. The coal within these basins is, however, not always continuous over large areas, but frequently occurs in isolated patches, capping the summits of the higher knobs of the country. As far as we have yet traced them, these basins will be separately described, taking them up in succession from the south-east to the north-west, and following each from the north-east towards the south-west. The general and local geological maps, with their accompanying sections and drawings, to appear with my final report, will represent fully the range, structure, and contents of these several basins and detached tracts of coal measures. It is hoped, however, that the following partial detials may be useful without the aid of those important illustrations.

The Allegheny mountain, pursuing a nearly east and west direction through Lycoming county, consists, at its southern base, of the slaty rocks of F. VIII., overlaid by the red shales and sandstones of F. IX. Denuding floods, acting upon these relatively soft materials, have imparted a gently rounded and undulating contour to the surface. Immediately upon them rests the sandstone formation, F. X. of our series, which, by its greater hardness has presented a great barrier to the waters, imparting bolder features and steeper slopes. This rock forms the main escarpment on the south of the Allegheny ridge, in its whole range across the State. The still harder and coarser rocks of F. XII., sometimes capping the mountain, give to it yet stronger features.

Nearly every where along the southern flank of the mountain the dip is northward, or towards its base; continuing thus for some distance, it then changes to the south, and forms a trough in the strata, in the higher tracts of which, we find the southern belt of coal measures. The Allegheny ridge, properly so called, usually embraces along its immediate summit, no stratum higher than F. X. Occasionally, however, it is capped by the coarse conglomorate of F. XII., embracing, in places, a characteristic "brown rock," and in a few knobs, the still higher beds of the coal series, to which the brown rock is an important index. Coal was discovered, and opened during the last summer, on the Allegheny mountain, at a point where the summit, is sufficiently elevated, to embrace all the shale here enumerated. The locality is about eighteen miles from Williamsport, on the old State road, between Newbury and Wellsboro'. Near the base of the mountain were found loose pieces of slaty sandstone characteristic of F. X. Above these rocks, which have a perpendicular thickness of about seven hundred feet, the ridge assumes a more gentle slope, and the soil presents evidence of being derived from the red shales of F. XI. This red shale is probably not more than thirty or forty feet in thickness. It is occasionally very ponderous and highly ferruginous, and shows indications of a bed of valuable *iron ore*, identical, probably, with one discovered in other places. Indeed, ore is said to have been found here. Overlying the red shale occurs the conglomerate, and loose pieces of other portions of F. XII. Its aspect is that of a white siliceous sandstone, imbedding small and scattered pebbles of white quartz. It is nowhere visible in place, and we can only judge of its position and thickness, by the loose fragments. It is probably about seventy-five feet thick. Above it occur no rocks in place; the only strata ascertained, being those developed in the excavations for coal. The following section exhibits the order of things from the top of the highest bench on the mountain, down to the conglomerate :

1st. Coarse micaceous sandstone, containing many vegetable organic remains.		
2d. Fireclay,	0 feet,	5 inches.
3d. Coal seam consisting of coal,		5
“ “ fireclay,		12
“ “ coal,	3 “	2
“ “ shale,		4
“ “ coal,	1 “	8
“ “ fireclay,		3
“ “ coal,		9
4. Fireclay,	6	0
5. Dark fireclay containing *fucoides.*		
6. Coal seam consisting of coal,	1	
“ “ shale,		4
“ “ coal,	1	
“ “ shale,	2	4
“ “ coal,	1	3
“ “ shale,		1
“ “ coal,		11
7. Black slate containing vegetable fossils, *fucoides, lepidodendron, sigilaria, equisetacea.*		
8. Brown sandstone rock.		
9. Conglomerate.		

This section is compiled from the measurements in several adjacent shafts, in which, it must be observed, the quality and thickness are not every where strictly the same. The main or upper coal seam, extends for more than a mile along a bench or terrace, which serves if carefully noticed, to mark its position. This flat, however, is narrow, the ground sloping rapidly away on both sides down to the conglomerate. Its course is rather irregularly northwards for nearly a mile, when it turns east, and gradually falls away towards Hogeland's run. The southern dip of the coal-measures, soon causes all the coal to disappear as we advance to the north, the red shale of F. XI. coming to the surface and marking the limit of the basin. Beyond these rise the sandstones of F. X. succeeded by the red shales and sandstones of F. IX. the latter constituting the principal part of the hill south of Larry's Creek, and the whole of those lying north of it, in the tract of country known as the Cogenhouse settlement. Excavations were made among the red shales of F. XI. north of the coal, in search of the iron ore which often occurs in this stratum. The shale in some places is exceedingly heavy, containing much oxide of iron; its color is also similar to that of some ores found in the formation, and might readily deceive an inexperienced observer into the belief of its being a productive iron ore. Further explorations, however, will probably result in the development of such in this vicinity.

Eastward the mountain is deeply intersected by the narrow valley of Hogeland's run, to the east of which, on Bope's mountain, exist fair indications of the coal measures, some pieces of the conglomerate being observed on the highest knobs, in a situation indicating the possibility of coal near the summits. It cannot, however, occupy an extensive surface, though if found, it would derive value from its proximity to the rail road running through the valley of Lycoming creek.

During the season which has closed, no examinations were undertaken further to the eastward along this basin; but coal is known to occur about Bear creek, and Little Bear creek, belonging, no doubt, to the same range. Its examination was deferred to the next season. The dips of the strata along Lycoming creek, indicate that this basin crosses the valley of that stream only a little above the mouth of Trout Spring run.

Towards the west, the mountain falls away to a branch of Larry's creek, called the Roaring Branch, beyond which it rises again to about the same elevation, presenting a flat area of more than a mile square on its summit. The conglomerate rock seems to lie about forty feet below the highest part of the hill, the outline of which is such as to imply the existence of the coal measures. A careful inspection of the surface was made, but no excavations undertaken. Further westward, the hills continue of nearly the same height, but examinations carried on in that quarter about the sources of the western branch of Larry's creek, did not result in the discovery of any coal. A few knobs, each containing a few acres, were occasionally found, possibly high enough to embrace one bed of coal, but they were deemed not of sufficient importance to justify any systematic excavations.

Explorations to some extent were made several years ago, for coal on some of these hills, but all the shafts were dug in the strata below the coal measures, and the highest ground lying in the centre of the trough, were entirely neglected. Excavations more judiciously undertaken, may possibly bring a better coal to light.

The geological map will show the range of the basin from Hogeland's run, across the sources of the different tributaries of Larry's creek, and thence across Pine creek, near the mouth of the First Fork, while the section along Pine creek will exhibit the position of the trough on that stream, and where the coal is to be sought for. In the high tongue of land between the First Fork and Big Pine creek, the hills have considerable elevation. Near the level of the stream, F. IX. just makes its appearance, being immediately succeeded by F. X., which occupies between eight hundred and nine hundred feet of the hills. Above this, the slopes become more gentle, the soil indicating the presence of the red shale. Here a bench in the side of the hill occurs, containing a white sandstone, referrible to F. XII. The rock is without pebbles, being a remarkably white and pure sandstone, readily disintergrating and furnishing a sand that would be well adapted for the manufacture of glass. To this succeeds another band of red shale, and in a high knoll we find another white sandstone similar to that just mentioned, above which are beds of *olive colored slates and* *argillaceous sandstone* holding nearly the position of the lower seam of coal, the existence of which, however, is not indicated. This is about the true place for the coal, if it occurs at all in the region. I would suggest to the owners of lands on both sides of Pine creek, lying a little above or below the mouth of the First Fork, to search for it above the white sandstone of F. XII. in the highest knobs. The lands occupying the head of the north branch of Ramsey's run, being near the centre of this basin, promise best—other things the same, to reward research for coal. Excavations have been made a little above the mouth of the First Fork, by those not familiar with the stratification of the region in a position *below* the rocks of F. XII., thin layers of coaly matter here presenting themselves in F. X. The quantity of dark slate, similar to that of the coal measures, is considerable and it is said, indeed, that a coal seam eight inches thick, was found. The exploration was, however, abandoned; and this will always be the case, when the search for coal is undertaken so far down in the series. On the west side of Pine creek, coal was once worked, for an old furnace near the Jersey Shore and Coudersport road. This tract will be explored during the coming season, though from all that we have this year learned, it cannot prove extensive or of much produtiveness.

The rocks along the Susquehanna river, are the argiliaceous sandstones forming the thick bands at the alternation of F. IX. and F. X. dipping at a considerable angle to the north-west. At the mouth of Lick run, these give place to F. X., having its usual characters of a brown slaty sandstone, but containing a few bands of a siliceous conglomerate; somewhat like F. XII., though darker. Above this sandstone lies the red shale of F. XI. in two separate strata, alternating with a grey sandstone, referrible either to F. X. or F. XII. The lowest of these red shales, is a bed sixty-five feet in thickness, containing two seams of *iron ore*, one only about six inches thick, the other twenty feet above it, being about ten inches. The ore is apparently good, but probably, not sufficiently abundant to be valuable.

A similar ore has been discovered on Queen's run, a mile and a-half north-east of the Queen's run mines, where it promises a greater quantity. Between the two seams of ore, occur buff colored and red shales. Overlying this red shale is a thick stratum of grey sandstone, analagous to that of F. X. about two hundred and fifty feet thick. This supports another thinner bed of red shale of F. XI. At the mouth of Queen's run, F. X. contains a seam of fire-clay four or five feet thick, which is a little too sandy, but may be worth working, if mixed with a more argillaceous variety. At the mines on Lick run, the strata have been bored from the highest ground down to the upper bed of the red shale. At different points, where this was done, the strata do not precisely correspond. One of the most important of the beds, a seam of coal is absent over a considerable extent, owing to a dislocation in the strata, or other causes not yet ascertained. In one of the knobs where the position of the coal appears to be represented by slate and sandstone, we have the following section:

Soil,	1	foot	9	inches.
Rotten coal, which, when under sufficient cover, is usually five or six feet,	1	"	6	"
Soft white clay, in other places worked as a fire clay,	6	"	9	"
Brown slate,	5	"	0	"
In this position should occur a coal seam six feet thick, containing sixteen inches of slate, nineteen feet below the brown slate, but it is absent				
Dark slates and flaggy sandstone,	76	"	5	"
Coal,	2	"	4	"
Dark slate,	9	"	7	"
Coal,	3½ to 5	"	0	"

The above section embraces the lowest coal bed of the basin. It is this seam which is at present principally mined by the Farrandsville company for their furnace, and other works. About fifty cubic yards are mined daily, costing fifty-seven cents per yard for the mining, the small coal not being counted. The coal is coked at the mouth of the mine, being transferred immediately from the cars to large heaps, where it undergoes the coking process without the aid of ovens. It is then sent by an inclined plane and rail road to the furnace at the base of the mountain. The second coal seam in the ascending order is not worked, the coal being impure; but the third, were the ground is sufficiently elevated to embrace it, has been wrought to some extent, yielding a better coal than either of the other two. It is now, however, nearly exhausted. This upper coal seam, lying usually near the surface of the highest ground, has generally an unsound roof, which unfits it to be mined. It measures commonly six feet in thickness. It is now removed to expose the fireclay which lies immediately beneath it, found to be of superior quality for the manufacture of fire brick.—This fireclay, from six to seven feet thick, is destitute of grit, and furnishes an admirable fire brick. Under it lies a bed of shale, containing a layer of *nodular iron ore* of no great purity or richness.

Beneath the lowest bed of coal, slaty sandstone and shales occupy a thickness of forty-six and a-half feet, succeeded by twenty-five feet of red shales, this by upwards of two hundred feet of grey sandstone, and this again by the lower bed of red shale. It is very remarable that we nowhere find the rocks occupying the position of F. XII., possessing the conglomerate character, while in every other neighborhood, in the same basin, as at the first fork of Pine creek and on the Tangascootac, as we shall show hereafter, this rock exists in its true type and features.

At Queen's run the same beds of coal and fire-clay occur which we see at Farrandsville, with this difference, that the uppermost coal seam is here under an ample covering and ranges over a tolerably extensive surface, being the only bed at present mined. Its thickness varies from five feet to three feet nine inches. The coal is superior, and finds a ready market along the Susquehanna.

The *fireclay* at this place is occasionally eight feet thick. A bed of coal about four and a-half feet thick occurs not far beneath it. This does not appear in the coal measures above Farrandsville. The other beds in the series are supposed to occur here, though their existence has not been positively ascertained. At the mouth of Queen's run fire bricks are made to a moderate amount.

They are manufactured at Farrandsville on a more extensive scale: about six thousand nine inch bricks being made every week, commanding about forty-five dollars per hundred. These are at present principally used on the spot for the furnace and other works. The furnace now in operation is built of stone, lined with the fire brick; it is fifty-four feet high. The diameter of the boshes was originally seventeen feet, but was lately reduced to thirteen. A powerful steam engine, having ten boilers, and estimated at one hundred and seventy horse power, when all are in action, propels the blast. From the description given of the coal measures of Farrandsville, it would appear that they furnish neither iron ore or limestone. The ore used in this large and ably constructed furnace, is brought from Montour's ridge, in Columbia county, being the fossiliferous ore of F. V. An inferior species is also procured on Larry's creek from the lower beds of F. IX., the former is transported about one hundred miles, the latter twenty-three miles. The limestone is that of F. II., from Nittany valley. The proportion of the materials employed in making one ton of cast iron, in October last, were as follows:

Coke,	6,500	hogsheads,	2,900	tons.
Fossiliferous ore,	3,200	"	1,428	"
Larry creek ore,	3,500	"	1,562	"
Limestone,	4,500	"	2,009	"

After the furnace had been in blast some time, starting in the month of October last, the cast iron produced was of a superior quality as a foundry iron, the yield being about fifty tons per week.

Passing to west side of the Susquehanna, the coal measures next appear on the Allegheny mountain, on the sourthern side of the Tangascootac creek. This stream runs nearly centrally along the basin for five miles, with a margin of comparatively broad and regular bottom lands on each side. Owing to the greater amount of denudation in the lower part of the valley, the coal measures do not there occur; but higher up they expand over a considerable extent of country, and acquire a thickness of several hundred feet. The growth near the south fork is open, consisting of fine hard wood and scattering white pines, and the surface changes from the steep mountain acclivities, seem nearer the river to gently rolling hills and extensive plains. The rocks along the valley of the Susquehanna for about six miles, belong exclusively to F. X. At the mouth of the creek, this formation rises nearly to the top of the Allegheny mountain, and caps the hill on the north side of the stream. The first appearance of F. XII., is where it covers the eastern extremity of the Allegheny mountain. Tracing it westward, it gradually comes in at a greater distance below the summit, until, three miles from the river, the coal measures occupy the mountain top, and the white, pebbly sandstone of F. XII. proper, lies under the summit, and crops out high up on the southern side. The hills on the northern side of the Tangascootac, do not reach the elevation of the Allegheny mountain, until we recede several miles, when a change of the dip to the south brings up the lower rocks. Along the northern side of the creek, the knobs are capped by F. XII. as far up the valley as the Forks. A little below this, the coal measures first appear on the north side of the stream, and finally further towards the west, occupy all the high ground between the heads of the two forks, but no coal occurs to the north of the North Fork, the hills then being capped by the conglomerate. The most eastern coal beds opened, are south of the First Fork, at an elevation of about 530 feet above the stream, which, in a course of 2½ miles to its mouth, descends thirty feet. The upper bed lies beneath a thick stratum of brown sandstone. It appears to be four feet thick, but at some distance in from the crop, a fault causes it locally to be only two feet. The quality of this coal is excellent. It is underlaid by a bed of good fire-clay. There occur about thirty-five feet of other strata, covering this bed over an area of perhaps fifty acres. Another coal seam, somewhat slaty, three feet in thickness, lies about thirty feet lower down, at no great distance under which is F. XII., forming a stratum nearly 100 feet in depth. This rock is here a fine sandstone, containing white pebbles, and disintegrates into a fine sand, well adapted for making glass. The next openings are on the south side of the creek, two miles above the Forks. The upper occurs near the top of the hill. It is four feet thick, including some small seams of slate and fire-clay. Over it lies a soft and very tenaceous slate clay, four feet thick. The coal is good; it breaks into rectangular pieces, and contains much mineral charcoal, occasionally in seams nearly half an inch in thickness, showing the fibrous structure of the coal vegetation. It is beautifully marked by thin alternating lamina of dull and splendent glance coal. A bed, supposed to be the same, has been opened at a lower level in a north-western direction, that being the course of the dip. At this latter place, its total thickness is four or five feet, including one foot of dividing fire-clay. Between twenty and thirty feet under this, occurs another coal seam, not well exposed, but apparently two feet thick; upon it rests two feet of fire-clay, and over that one foot of black slate, surmounted by more than ten feet of blue slate. The rocks underneath the coal, are entirely concealed, but the conglomerate cannot be far below. On the southern side of the Allegheny mountain, there are two small *benches* near the summit, at some height above the steep slope, caused by the conglomerate. The lower of these contains the "brown rock," while the upper one, probably, embraces a bed of coal. The hills north of the North Fork constitute the northern margin of this coal basin. They are higher than the hills around, being capped by the conglomerate. Between the north and south forks, coal measures extend through the hills for some distance. Indications of *iron ore* present themselves in F. XI., in a ravine, two miles above the Forks. Between five and six miles from the mouth, the coal measures are within seventy-five feet of the beds of the streams, the hills rising about 250 feet higher. Further westward, the surface becomes smoother, and the extent of country embracing the coal measures, much greater; but the close of the autumn confined our investigations in this basin, to the neighborhoods already described. The distance across the basin, from the Allegheny mountain to the hills north of the North Fork, is apparently about five miles, but the actual area of the coal is more circumscribed, owing to the numerous vallies of denudation. In the district hitherto explored, the indications of iron ore among the coal measures, are unpromising.

This basin is prolonged, no doubt, across the head streams of Beach creek, and embraces the coal measures at Snow Shoe and Phillipsburg.

Though the eastern extremity of this basin has not been yet explored, we have ascertained with tolerable certainty, that it crosses the Loyalsock, near the mouth of Plunkett's creek. The rocks opposite the mouth of Mill creek, the first large stream above the mouth of Plunkett's creek and along the whole extent of that stream, dip gently to the S. S. E. The conglomerate capping the hills may be traced for miles along their summits. At the very head of Mill creek, the lower beds of F. X. replace it on the hill tops; and below the mouth of that stream on the other side of the Loyalsock, F. IX., rises two hundred feet in the hill, the rest consisting of the flaggy brown sandstones of F. X. In the latter rock occur thin bands of a poor *arenaceous limestone*, hardly rich enough in lime to be of any value. It assumes a singularly pitted or worm-eaten surface from atmospheric action. It is sometimes four feet thick. On the top of the hill above referred to, at an elevation of about one thousand feet above the stream, occurs the conglomerate, apparently about forty feet thick, dipping S. S. E. The summits along the creek were minutely explored, from Mill creek to Lick creek, a tributary of the little Loyalsock, without the discovery of any thing of economical importance.

The topography of this part of the State map is exceedingly erroneous.

A remarkably abrupt anticlinal axis exposing the red sandstones of F. IX., on the stream next west of Lick creek, (another mill creek,) was traced in a west by south direction, crossing Pleasant stream, Lycoming creek, half a mile above the mouth of Pleasant stream and Pine creek, six miles above the mouth of the First Fork, beyond which it deflects a little more to the south, being the great axis separating the Snow Shoe from the Karthaus basins. Nowhere does it exhibit dips so great, as along the waters of the Loyalsock.

The considerable angle at which the rocks dip north of the little Loyalsock, causes nearly the whole thickness of F. IX. to crop out in one hill, though its perpendicular depth is about one thousand feet. The olive and greenish slates of the underlying strata at the alternation of Fs. VIII. and IX. also appear. They have been erroneously fancied to contain *copper ore*. Formation VIII. itself, comes to the surface near the confluence of Mill creek and Lick creek, where it includes a thin bed of *fossiliferous limestone* of good quality for making lime. Near the limestone, rises a brine spring, the water of which furnishes a blackish sediment, by evaporation.

The bottom lands of the Loyalsock are wider than those on most of the other streams in the northern counties, and contain many good farms. The neighboring hills are precipitous and rocky and remarkable for the distinct features of the *benches* along their sides. Their height varies from a few hundred to a thousand feet; one of them proved to be nine hundred and eighty-eight feet by measurement. In this hill, which is a mile above the mouth of Elk creek on the north side, the strata as far as ascertained, are as follows. For the first thirty feet above the stream, red shales of F. IX. Upon the red shales a blue sandstone. Above this occur flaggy argillaceous sandstones, somewhat reddish, but more commonly blue and gray. The flat loose pieces of this rock conceal most of the lower beds, resting on the side of the hill, although it slopes at an angle of nearly seventy degrees. A somewhat reddish and heterogeneous calcareous rock, in large blocks has fallen a short way down to the water's edge. It is an indifferent limestone, probably unfit for use. At the height of five hundred and sixty-eight feet, occurs a bold bench or perpendicular cliff, formed by a bed of coarse white sandstone and conglomerate, about eighty feet thick, embracing a curious variety of white shale, one foot in thichness. Receding from this escarpment, occurs a shelf or terrace of very gentle slope, from which the hill rises by a steep and regular acclivity to the very summit, which is covered with scattered pieces of coarse conglomerate. This hill and the adjoining rivulets were closely examined, and a few excavations were made without discovering any trace of either iron ore or coal: which latter ought to have presented itself, had the bench described been formed by the conglomerate of F. XII. A band of red shale near the summit, belongs probably to F. XI. and may possibly contain some iron ore. The summit of this hill is a broad flat, used as a pasture, and the only artificial enclosure required for the cattle, is a single bar put across a narrow passage between two rocks.

On the south of Loyalsock, opposite the last hill, a bench exists apparently on a level with the top of this, while a knob forty or fifty feet high rises above it, composed of sandstone and conglomerate.— Under this last bed, is a thin seam of coal, one foot thick, overlaid by a foot of slaty cannel coal, and resting on a floor of black bituminous shale. The same band of coal was readily discovered in other places, at the base of similar knobs in the neighborhood. No iron ore was found. The coarse conglomerate occupies only the very highest knobs. The stratification here described, belongs to nearly all the hills lying on this creek.

Elk Lake is incorrectly placed upon the map; it should be five miles further west, being by the scale of the map one inch out of its true position. The country around Elk creek, consists of Fs. IX. and X. Hogeland's branch traverses the red shales of F. IX., throughout its whole course; it is a rapid stream, descending by a series of water falls, from twenty to forty feet high, over the harder sandstone shelves, in the red shale. The scenery at some of these waterfalls, is wild and picturesque in in a high degree.

Near the top of the hills around the head of Hogeland's branch, we find a stratum of poor bluish limestone one foot thick, and among the red shale 200 feet lower down, two others belonging to the alternations of Fs. IX. and X. A mile or two east of Hogeland's branch, many loose pieces of the conglomerate are scattered about in large boulders, between the head of that stream and the forks of Loyalsock. The rock is valued by the inhabitants for making mill stones. A knowledge of the stratum from whence they are derived, would prove a guide in seeking for the coal measures.

On the highest parts of Bennett's ridge, at the head of Plunkett's creek, it lies in place dipping N. N. W. four degrees, and under it we find a bed of the red shale of F. XI. It was traced for several miles near the heads of Pleasant stream and Plunkett's creek. At two or three miles below the head of Wallace's run; though the ridge is very high it does not occur. Bennett's ridge runs north-east through Elkland township, south of Pleasant stream: The ridge between Pleasant stream and Rocky run, contains only the lower rocks of F. X. This is about ten miles above Ralston. Between five and seven miles east of Ralston, the conglomerate is well exposed, capping the hills and forming an abrupt or sometimes overhanging wall, twenty-five or thirty feet high, full or dark passages and deep holes. It is not practicable to ascertain the existence of any bed of iron ore which may occur beneath this rock, without a considerable amount of digging. Approaching Ralston, the conglomerate gradually descends lower into the hills, which from the deepening of the valley of the run, has an elevation of at least 1,000 feet above its bed.

Ralston.

The next place of importance to describe, is Ralston, at the mouth of Stony or Rocky run, on Lycoming creek, twenty-six miles above Williamsport, at the present termination of the Williamsport and Elmira rail road. The hills, which are about one thousand feet high, contain, at their base, the red rocks of F. X., surmounted by the conglomeritic limestone. The centre of the coal basin crosses Lycoming creek, near the mouth of Dutchman's run, one mile above Rocky run. The anticlinal axis, causing the southern margin of this basin, crosses near the mouth of Pleasant stream, while the other axis, bounding it on the north, passes near the mouth of Roaring creek. The hills, including the coal measures, occupy a range of country east and west, nearly ten miles in length; but the coal is not continuous over all this extent, being interrupted by deep vallies of denudation. The principal localities of the coal are on a branch of Rocky run, between that stream and Dutchman's run, on Red run, the other side of Lycoming creek, and on Frozen run, near Astonville. From Ralston, a wagon road, at a grade of one foot elevation to the rod, ascends three miles to the mines. The height of the coal above the creek at Ralston is about eight hundred and seventy-five feet, while Ralston itself lies eight hundred and eight feet above the tide. On Dutchman's run, a remarkable slide in the face of the hill has laid bare F's. X. XI., and XII, On the road leading to the mines, and below the conglomerate, in a bed of dark shale, there is a valuable band of *iron ore*, lying only four feet beneath the rock, from which it is separated by a layer of brown shale. The bed of ore has not been fully exposed; it promises to be about six feet thick. The ore occurs in irregular knotty lumps, closely bebbed in a soft reddish and white shale. It forms about one-half of the stratum, and consists of nearly a white crystaline protocarbonate of iron, somewhat resembling a fine grained sandstone. This is apt to be encrusted with the brown or red oxide. These balls are very solid and heavy, becoming more massive as we penetrate deeper in from the crop. In the other half of the bed, which is principally shale, occur scattered balls of the same ore, of a blotched red and white appearance. This ore is admirably suited for the manufacture of foundry iron. I shall present its chemical composition, when describing it as it occurs on Frozen run, where it is converted into iron. It is contemplated to build a furnace, for smelting this ore, on Rocky run.

The conglomerate and sandstone stratum, of F. XII., varies from forty-five to one hundred and fifty feet in thickness; the top of this rock is marked by a terrace, gently receding from the front of the hill to an abrupt slope, formed by a bed of white sandstone, about sixty feet in thicknees. Between these two sandstone beds we find a seam of rather slaty coal, from eighteen to thirty inches thick, underlaid by thirty inches of slate. Over the sandstone occurs another bed of coal, six feet thick, but not of superior quality, the lower part of it consisting of slaty cannel coal, and the rest being rather hard. It includes two bands of slate, one eight inches, the other near the bottom, three inches thick.

Another coal seam, between two feet six inches, and two feet ten inches thick, occurs seven and a-half feet above the former. It contains three inches of slate near the middle, but supplies an excellent coal for coking, and is much superior to the thicker seam beneath it. Above this coal we find a bed of shale, containing large nodular balls of *iron ore*, the quantity of which has not yet been ascertained; and a little higher, another seam of coal one foot in thickness. Next occur seventeen feet of sandstone, and then a bed of slate, containing balls of good *iron ore*, in considerable abundance. It is thought that this layer may furnish three feet of iron ore. Still ascending, we find eighty feet of brown sandstone, then a fireclay two and a-half feet, and a seam of coal one foot thick, blue slate three feet, brownish, and then white sandstone forty feet, and above this a bed of coal, never fully opened, but stated to be four feet thick, presenting a good appearance at its outcrop. Crowning the highest part of the hill occurs a bed of conglomerate, sixty feet in thickness, less coarse than that of F. XII. The dip of these strata, at the mines on Rocky run, is gently westward on Dutchman's run; on the opposite side it is towards the E. S. E., while a few miles further up the main branch of Rocky run, it is toward to the north-west about four degrees.

A somewhat curious feature in this hill, are the swamps occurring on its very summit; the largest occupying several acres, entirely destitute of timber, and containing a deposite of *peat*, at least fifteen feet in depth. A rare tree, the *rowan tree or witch hazel*, occurs on the borders of these swamps.

On Red run the strata are nearly the same as at Ralston. Beneath the conglomerate, the shale containing the iron ore is thirty-four feet thick, and underneath that is a sandstone one hundred feet, succeeded by another bed of red shale fifty feet in thickness. These two red shales correspond with those at Farrandsville, already described, excepting that the iron ore occurs at the latter place in the lower bed.

Frozen run enters Lycoming creek on the west side, below Rocky run. At a spot called Astonville or Oaksville, a furnace is in operation smelting the ore found in the red shale. The coal measures extend to the head of Frozen run, the mines being on the hill between Frozen run and Red run. The strata here are very similar to those at Ralston, except that the coal beds are not quite so thick. The elevation of the red shale containing the ore is seven hundred and ninety feet above the rail road. The ore band varies from four and a-half to six feet in thickness, the upper half containing the richest ore, which, remote from the outcrop, is nearly solid. Upon it rests four feet of shale. Ascending, the rocks are conglomerate and sandstone, eighty-five feet, coal eighteen inches, brown shale, a heavy bed of sandstone, coal two feet four inches; and a little higher, another coal, eighteen inches producing a good article for coking. This last lies nine hundred and sixty feet above the railroad at the mouth of Frozen run, and the hill rises about thirty feet higher. Near the base of the hill is the usual band of limestone occurring near the top of F. IX. It is too impure to be employed as a flux in the furnace, limestone for that purpose being brought from Williamsport, and employed in the ratio of one ton for each ton of cast iron made.

The furnace at this place is forty feet high, and ten feet six inches in diameter at the boshes. It has been in successful operation only at intervals for about two years; but has recently produced an iron of very excellent quality for foundry use: the castings being highly esteemed.

Crossing Laurel hill by the road up Trout run, a north dip is observed on the south side of the stream, and a south dip on the north side, indicating this as the position of the synclinal axis of the coal basin. Ascending the hill we have indications of F. IX. for an elevation of from three hundred to four hundred feet. This is succeeded by F. X.; on the upper side of which we find the two bands of red shale constituting F. XI. *Iron ore*, in loose pieces, was found near the upper of these beds of red shale, and not far from the summit of the hill, which is surmounted by the coarse white sandstone and conglomerate of F. XII. Above this last rock, one of the lower beds of coal may possibly exist, where the knobs rise to a sufficient height from this level. Little doubt can prevail, that the red shale below the conglomerate includes a band of iron ore similar to that found at Ralston.

The country south of Laurel hill is extremely rough, being covered by Fs. IX. and X.; but that north of the hill is more gently undulating, F. IX. alone capping the hills and producing a soil fit for farming.—The northern anticlinal axis of the Ralston basin crosses the road a little south of the county line, while the southern axis passes near the head of Trout run.

The next place in our progress west, where this basis contains coal, is on the first fork of Pine Creek. Heavy masses of conglomerate strew the flats along the first fork, about three miles from the mouth of Bear Run, which heads near Larry's Creek. We no longer find F. IX. above the streams, but it rises to their level near the Block House fork, and a little below the old English mills. The hills are between seven hundred and eight hundred feet high, containing about one hundred feet of the conglomerate, supporting one hundred feet more of higher strata. On a stream known as Three Mile, or Porcupine Run, opposite Wolf Run, the conglomerate, and above it, the brown sandstone, are well exposed. Between them no bed of coal was discovered; but above the sandstone, a coal-seam was found consisting of two bands, each about one foot thick, separated by a layer of hard shale. The lower band in this seam is a beautiful black shining coal. Below it lies a bed of hard blue shale. Much search was made for iron ore, but without success. Whether other beds of coal exist in this neighborhood, is uncertain; but the country seems well deserving of further investigation. The conglomerate caps the hills on both sides of the fork, a little distance north and south from the spot where the coal was found. On the east side of the fork, and on the Block House Branch, the indications of coal are less promising than on the west side. An unsuccessful search was made for the iron ore of F. XI. A ferruginous band in the red shale about one hundred and fifty feet beneath the conglomerate, implies that ore might be found here if an adequately minute exploration were made, assisted by proper diggings. Specimens seemingly of good quality were found sticking in the upturned roots of trees between Porcupine Run, and the old English mills.

About the time these discoveries on the first fork of Pine Creek were made, a person seeking for limestone on a wild tract a few miles to the west, stumbled upon a bed of coal: a continuation perhaps of the seam above described. In tracing the basin in that direction, other beds were discovered and opened, to which I shall now refer. The locality is at the sources of Otter, Day's, and English's runs, which empty into the first fork, and of Trout run, which empties into Big Pine Creek, below the second fork; the property belongs to General Keim of Reading. The surface is gently rolling, but very elevated; the obscurity of the exposures, and a considerable amount of dip in the strata, causes the tracing of the coal in this neighborhood to be rather intricate, as a section made across the basin here would show.

On the very highest lands to the north and north-west, F. XII. either caps the summits or leaves very little room for the "brown rock" which overlies it. A dip to the south carries down these rocks, and soon brings in the coal at a level considerably below the tops of the hills; but the ground continuing to slope also to the south and east, renders it difficult to determine how far the coal extends in those directions. About three miles north on the road towards Babb's, the hill suddenly falls off about two hundred feet, exposing the upper band of F. XI. and the upper part of F. X. brought to this elevation by the southern dip. Still further north, the level of the country is much lower than where F. XII. occurs. Where the road crosses Otter Run, the "brown rock" above the conglomerate just rises to the surface, forming the lower part of the bank; above this is the lowest coal seam, which is two feet six inches thick, containing a thin band of fireclay, and underlaid by another bed of fireclay two feet thick. The outcrop of another coal seam, shows itself a little higher up in the same digging. The fire-clay mentioned is of good quality, suitable for the manufacture of fire-bricks. Another coal bed was found twenty-five feet above in a neighboring bench in the hill. It was opened too near the surface to ascertain its quality; its thickness is three feet and eight inches, including two inches of slate. Below it lies a bed of fire-clay, similar to that of the middle coal seam. The extent of this upper bed cannot be great, but the other beds underlie probably fifty acres of surface, or perhaps more.

Tracing the conglomerate towards the north, it appears near the top as a coarse pebbly rock, and lower down, as a reddish brown sandstone. The thickness of the whole stratum is about one hundred and fifty feet. On the northern slope of the hill towards the old English settlement, F. XI. appears. A careful search was here made for the iron ore.— About two hundred feet lower down, the soil indicates the lower red shale bed, and here possibly the iron ore may exist. The hills north-west of the coal openings rise more suddenly, and contain the conglomerate. How much further the coal measures extend towards the south and east, can only be ascertained by systematic diggings and accurate measurement, beyond the resources of the survey. At some places in those directions, the elevation seems to be as great as at the coal, but a change of dip must occur before we proceed far in that course. The brown sandstone is exposed below the coal on Otter run.

Coal may hereafter be found at other points on these high lands between the First Fork and Big Pine creek, but it cannot occupy much extent of surface. It may be worth the attention of the owners of lands lying at the head of the south-west branch of Otter run, about five miles from Callahan's, to excavate for coal, as the appearances here are indicative of the coal measures, and the conglomerate does not reach to the highest summits of the country. Examinations were made here, both for the coal and the iron ore of F. XI. A pit dug in the red shale about twelve feet, did not, however, bring either mineral to light; but it is probable that the ore exists, if at all, in this neighborhood, chiefly in the lower bed of red shale: for we subsequently found it there on the west side of Pine creek, nearly opposite Callahan's. At this spot it is not, however, well exposed, being only about six inches thick, and composed of hollow ellipitical nodules, containing sometimes an undecomposed blue centre.

Tome's creek enters Pine creek on its west side, heading near the corner of Lycoming county. The anticlinal axis north of the coal basin we have been describing, crosses the main creek just above their junction. Ascending the mountain by a road crossing over to the Coudersport road, the rocks of F. IX. show themselves for the first two-thirds of the way up. Near the top of the formation, we meet with two beds of the *blue calcareous conglomerate*, and another about one hundred feet higher up, among the lower beds of F. X. which continues for one hundred feet more. Above this, we find a bed of iron ore in F. XI. at one time dug in several places. It varies in thickness from two to three feet. From the iron ore to the top of the hill, a vertical space of forty feet, the rock is the white sandstone of F. XII. presenting at the summit many pebbles. Near Herod's, on the Coudersport road, the surface is a little higher than the conglomerate, and consequently a small bed of coal, one foot in thickness, has been found. This coal belongs to another basin lying considerably north of the anticlinal axis above mentioned, and entirely out of the range of the second or Ralston basin. In this neighborhood, the conglomerate and sandstone of F. XII. yield a white sand, which would be well adapted for making glass.

The next coal basin toward the north, or the third in order, is that of Blossburg, on the Tioga river. The hills on the south side of the river, for a few miles above Blossburg, are capped by the conglomerate; the red shale rocks of F. IX. come out on their southern slopes, the dip to the north being considerable. No coal has been found on that side of the river, excepting near Blossburg; though it may possibly exist south of the valley, near its source. The coal formation extends eastward nearly to the head waters of Tioga river, but has not the thickness which it attains further West. On a stream called Little Falls run, nine miles above Blossburg, openings were made some years ago, under the direction of one of the mining companies of Blossburg, developing a seam of coal about three feet thick, and small bands of iron ore. A bed of conglomerate, twenty feet thick, occurs here between the layers of slaty sandstone, dividing this last rock into two portions; the lower one being of considerable thickness, the upper slaty sandstone sustaining the seam of coal. Above the coal rests a bed of black shale nearly twenty feet thick, containing *kidney-formed iron ore* of excellent quality, though not abundant; above which are three layers of a poorer species of iron ore in flat slabs, measuring four inches in thickness. Over the shale with ore, lies a bed of slaty sandstone, extending to the summit of the hill. The dip of the beds at this place, is towards the north. At the eastern side of this hill, the sandstone forming the summit, containing some small pebbles, resembles somewhat a conglomerate. It includes some small bands of coal.

The next stream towards the west, which furnishes a good view of the strata, is Fellow's run; but no coal has been opened upon it. About three miles above its mouth, this stream descends into a beautiful and picturesque water-fall, the whole height of which, embracing three leaps, is sixty feet. Below the lowest of these, the conglomerate and sandstone rock rises perpendicularly to a greater height than that of the falls. The height of the top of the water-fall or of the conglomerate rock, is about four hundred and thirty feet above the bridge at Blossburg, while the elevation of the same on Morris' run, lying further west, is about three hundred feet. On Morris' run, about three miles above its mouth, at the height of three hundred and twenty-two feet above the Blossburg bridge, a seam of coal was opened some years ago, more than six feet in thickness. It has a roof of fireclay about six inches thick, which must be mined with the coal. Beneath the coal lies a bed of shale, twelve feet thick, said to rest on another seam of coal, probably a thin one; and below this is found a thin bedded sandstone, extending for a moderate depth to the top of the conglomerate. Higher up the run, in endeavering to remove some of the loose material covering the rocks, a large lump of excellent kidney ore was found, wighing at least two hundred pounds. This had fallen, no doubt, from some bed in the side of the hill. Pieces of coal occur in the swampy ground, but whether they belong to a regular bed, can only be determined by draining and digging.

About forty feet above the large vein of coal, many large nodules of a rich iron ore were discovored among the roots of an upturned tree. Their abundance was such as to indicate a considerable band of the ore. A little lower lies a bed of dark blue shale, enclosing a seam of slaty cannel coal, of unknown thickness. Other beds of coal may possibly have been met with still higher up, or perhaps the exposure seen was only the outcrop of these same seams repeated; little satisfactory information being at present preserved concerning the earlier diggings in this vicinity. The access to these localities, is through a succession of thick woods and tangled laurel swamps; though the country is not unsuitable to the construction of roads.

As some anticipations exist that the coal will be developed in Elk mountain, the southern margin of the basin, it may be desirable to present in this place a general description of its summit. Near the top of a high ridge between the forks of Carpenter's run, a tributary of the Tioga, from the south, occurs a stratum of fine grained white sandstone, which readily disintegrates into good glass maker's sand. Below this, we meet many loose pieces of conglomerate, which occurs in place 100 feet higher up, constituting benches within fifty feet of the summit, and about 500 feet above the Tioga river, This rock is about fifty feet in thickness, being in some places a coarse conglomerate, in others passing into sandstone. This bed caps the whole ridge opposite the mouth of Fellow's run, for a mile or more back from the river. Its dip is towards the N. N. W. The same rock has been encountered further east on the same side of the Tioga, forming the summit of the hills. It is in vain therefore to look for workable coal in these positions; the most that can be hoped for, being a small imperfect seam, occasionally found beneath this stratum, about ten inches thick.

The rocks in the bottom lands along the river above Blossburg, belong to F. X., and contain some layers suitable for whetstones. Formation IX. does not show itself.

Coal run, upon which some of the mines above Blossburg are situated, enters the Tioga from the north-east. Its source is not quite a mile from the river. The hills around it are 400 feet above Blossburg, A nearly continuous section of the strata was obtained on this run. The highest bed measured, is at an elevation of about 284 feet above the river, above which occurs a considerable thickness of rocks without exposures.

Section at Coal Run.

Brown sandstone,		
Kidney ore, shut out by the sandstone,		
Shale, a thin bed,		
Coal, chiefly cannel coal,	3 feet.	
Fireclay,	2	6 in.
Shale,	15	
Coal,	1	6
Fireclay,	2	6
Shale,	2	
Nodular ore,		4
Blue shale,	3	
Coal,	3	6
Fireclay,	2	6
Shale,	10	
Sandstone with vegetable remains,	30	
Fireclay,		6
Cannel coal, with two seams of slate, one 1 foot the other 3 inches thick,	2	7
Shale, containing rich kidney form ore, the aggregate thickness is about 6 inches, all lying within 3 feet,	32	
Coal *too far below* the ore to be worked with it,	1	
Sandstone,	30	
Cannel coal,	2	
Olive colored shale,		
Sandstone with vegetable remains, passing into a conglomerate towards its lower part.		

Below these strata, we meet with the red shales of F. X., alternating with sandstone. Diggings have been made in this red shale, for iron ore, two unimportant bands of which were discovered. Near the upper red shale, is a bed of fireclay.

The next vertical section measured, is on Bear Creek, north of Coal Run, but on the same side of the river. A thick bed of sandstone, part of which is pebbly, and about fifty feet thick, forms the upper rock in this hill, above the coal-mines. The following series, commencing a few feet below the bottom of this rock, exhibits the composition of this hill:

Coal, variable, but sometimes	1 foot,	6 inches.
Shale, containing four inches of iron ore, ten to twelve feet,	12 "	0 "
Coal,	3 "	7 "
Fireclay, two to three feet,	3 "	0 "
Coal, lower half cannel coal,	1 "	2 "
Dark sandstone, with purplish stripes,	12 "	0 "
Coal,	1 "	6 "
Stratum not measured,		
Sandstone, imbedding pebbles,	30 "	0 "
Bed containing iron ore, three to five feet,	4 "	0 "
Stratum not measured.		
Sandstone.		
Stratum not measured.		
Red and yellow shales of F. XI.		

The upper coal occurs on the south side of the creek, where it is one foot six inches thick; but on the north side, it is entirely wanting. The ore in the next stratum is good, but small in quantity; this bed is also visible on Coal Run. The next bed is the main coal seam at Blossburg; it has been opened in five different drifts, two on the south side and three on the north side of the creek, at an elevation of about two hundred and eighty feet above the rail road, not quite a mile distant. The quality of this coal is somewhat injured by the amount of sulphuret of iron occasionally present, from which the chief part of the bed is comparatively free, having a fine brilliant lustre. A fault crossing the three drifts on the north side of the creek in a north-east and south-west course, throws down the coal three feet. Large quantities of this coal are carried down the Tioga valley in the winter.—The fireclay under this coal contains fossil-stems of the genus *cactus*. At its outcrop occurs a large deposite of exceedingly tough clay, derived from this bed, well adapted for the manufacture of fire-bricks. The eighteen inch seam of coal was at one time partially mined, but has since been abandoned. The sandstone which underlies this, is rather remarkable, passing in its lower beds into a coarse conglomerate. We have not yet determined whether this bed marks the bottom of the coal measures. Under it lies another bed of sandstone, and beneath that the red shales of F. XI. Below the conglomerate, a rather singular band of ore has been met with, which thinned out after being pursued for a few feet in. It would justify further exploration. The shale containing this ore is nearly five feet thick, consisting largely at its outcrop, of long elliptical balls of a very argillaceous brown ore, lying closely adjacent to each other, and forming more than one-half of the stratum. Each elongated nodule, consists externally of a series of concentric crusts, which readily peel off by exposure to the atmosphere. Beneath the balls, lies a nearly solid layer of a heavy yellowish-gray ore, about six inches thick, having a true oolitic structure. These beds appear to be shut out by the overhanging sandstone, at a short distance in from the surface. Other excavations have been made for ore in the other red bands lower down in the series, but unsuccessfully. The conglomerate and sandstone of the two beds described, strew the hill-sides in great quantity, and furnish an excellent building material.

Half a mile north of Bear Creek and parallel with it, is the denuded valley of East Creek, on the northern side of which the hill is capped by a thick bed of sandstone passing towards its lower part into a conglomerate. Underneath this lies a stratum of brown shale, fifteen feet thick, containing four bands of nodular ore, included in a thickness of seven feet of shale, the aggregate thickness of the ore being thirteen inches. This bed of ore is the most promising hitherto met with in the region. The chemical composition of this ore will be seen in Cap. VI.

Below the shale is a thin layer of sandstone; then a black shale, including a thin seam of cannel coal; and fifteen feet under this, it is said another seam of ore occurs fifteen inches thick; and beneath it again a bed of coal twenty-one inches in thickness.

A considerable southern dip occurring between East creek hill and Bear creek hill, the sandstone capping the summit of the former, is probably the same as that which underlies the coal openings along the latter. On Limestone Hill, half a mile further north, the highest rocks are the thin beaded sandstones of F. X. extending from within two hundred feet of the base to the summit. At its base the limestone so often found, at the alternation of F. IX. and F. X. shows itself, with a thickness of at least eight feet, consisting of heterogeneous materials, closely cemented by calcareous matter. It has a variegated aspect, like certain *breccais*. It is a durable rock, well adapted for building stone, but it is too impure to be converted into lime. It is underlaid by a blueish, micaceous sandstone, furnishing an excellent building stone. The dip here is at an angle of five degrees towards the S. S. E. North of Limestone Hill, some of the lower layers of F. IX. appear above the bed of the valley. In one particular band of red, micaceous sandstone, occur numerous mutilated remains of a highly curious fossil fish, *the Holoptychui of Agassiz*. Further north, still lower rocks appear.

On the west side of the Tioga river between the heads of Johnson's creek and Boon's creek, three miles from Blossburg, the coal measures occupy the hills, though little is known of them at this locality. The following account of the stratification on Johnson's creek, was furnished by the superintendent of the mines at Blossburg. Near the summit occurs a shale containing nodular iron ore; below this, a bed of coal two feet two inches thick; then fifteen or twenty feet of sandstone, then another coal seam embracing two feet five inches of coal, fifteen inches slate and twenty-two inches coal; in all, a bed about six feet in thickness.

On West Hill near the mouth of Johnson's creek, there is a sandstone passing into fine grained conglomerate about fifty feet in thickness, underlaid by four feet of olive colored shale, containing about two feet in the aggregate, of *iron ore* near its outcrop. The lower portion of this ore is of a greenish gray color; the upper is reddish, and sometimes oolitic in its structure.

At the outcrop, the greenish gray kind is one foot four inches thick, the red ore nine inches. The whole bed shows signs of diminishing in thickness, when followed in towards the hill, but possibly it may again augment. At the foot of the hill a considerable deposite of *bog ore* has been collected, apparently from this stratum.

From the foregoing remarks, it will appear that the principal supply of coal at Blossburg, must come from one seam, and that this occurs in greatest thickness on Morris' run, six miles from the village where it is about six feet from floor to roof. No bed of iron ore has been yet discovered, which will justify, I conceive, the construction of a large furnace, though some of those already opened may prove sufficiently productive when further explored.

Crossing this coal basin at a point further west, in a south-east direction from the south-west corner of Charlston township, the following features present themselves. The hills in this part of the township are capped by F. XII., the material used in the construction of the Court House at Wellsborough. Passing south-eastward crosses the forks of the First Fork or Babb's creek, the conglomerate is seen to occupy the tops of all the high ridges, being no where met with below the summit. The upturned roots of the trees furnish no indications of coal smut. Southward to the head waters of the First Fork, near the Blossburg road, the conglomerate caps the summits. In so wild a country, it is impossible always to pronounce with positiveness upon the non-existence of coal in a part of the basin like this, where a slight dip may bring in, unperceived, the lower part of the coal measures. This neighborhood was carefully examined, and if the coal does prevail, it cannot cover much extent. Further west over Wilson's or Yarnall's creek, entering the first fork at Baab's, and heading towards Wellsborough, the coal measures have been discovered, and the coal opened on the west side of the stream. On the east or opposite side, coal smut was also found by us at the mouth of Wilson's creek. The dip is gently northward; and about five miles above or towards the north, it is southward, forming the basin, in the centre of which lie these insulated patches of coal measures. The tops of the hills at the two boundaries mentioned, consist of the conglomerate, on the very highest knobs or the brown rock above it; gradually descending to a rather lower level in the basin, they have over them for a considerable extent of surface, a moderate thickness of strata, which may be found to contain one seam of coal. Between one hundred and two hundred feet below the conglomerate, there occur abundant signs of a bed of iron ore, visible along the brow of the hills on each side of Wilson's creek. Some amount of excavation, however, would be requisite to develope it. Along Wilson's creek, F. X. is not very thick, the hills containing the coal measures being apparently not more than six hundred feet high, while F. IX. just appears above the bed of the valley. The coal occurs between two and three miles above Baab's, at the mouth of Wilson's creek. It overlies a bed of sandstone reposing above the conglomerate. The floor of the coal is a dark brown shale. The seam is double, the upper portion being one foot in thickness, the lower, eighteen inches, both of good quality. They are separated by a band of dark shale one foot in thickness; the roof of the coal bed consists of black shale full of vegetable fossils. The hill rises only about thirty feet higher than the level of the coal, and presents no indications of another seam, or of a band of iron ore, though much search was made. Half a mile north from the opening made in the coal, the conglomerate rock is finely exposed, exhibiting itself in a bed of about thirty-five feet thick. Receding a little from the front of the hill, a bench rises about thirty feet from the conglomerate. On the top of this flat the upturned roots of the fallen trees, disclose numerous fragments of iron ore. The indications of ore are tolerably abundant from this point across to the Stony Fork, and the smut of the coal is also traceable throughout the same tract, but whether more than one coal bed occurs, cannot be ascertained without much excavation.—The conglomerate lies high, but some points of the surface tower a little above it. The outline of these high lands is undulating, the growth is open, and would furnish much timber adapted for making charcoal. On both sides of the Stony Fork the conglomerate crowns most of the hills until we advance several miles up the stream, where the lower rocks form the surface. This formation is well exposed in this vicinity, forming often an irregular line of escarpment around the brow of the hill for many miles in extent, where enormous blocks, dislodged from the stratum, open lanes and passages between them and the main bed. In the bed of the valley of Stony Fork, the impure, calcareous rock near the top of F. IX. sometimes shows itself. About three miles from the mouth on the east side, a very ferruginous spring appears, depositing a large mass of brown ochre. A little above this spring, an excavation was made in search of ore, and a band of small compact nodules, whitish within and coated with a brown crust, was found, imbedded in a shale. After penetrating to a depth of a foot and a half, a copious ingress of water arrested the digging. This band of ore, is conceived to be a continuation of that already discovered in so many places in F. XI. The same band was found some years since, several miles to the west, on Pine creek. On the west side of Stony Fork, the red shale below the conglomerate is very ferruginous.

Between the layers of the conglomerate, a short distance from the bottom, a thin band of black shale, readily mistaken at first for the crop of a seam of coal, was found. As it is somewhat continuous, though only one foot thick, it is desirable thus to mention its position, lest it may mislead. Over the conglomerate on the same side of the stream, the ground rising twenty or thirty feet, a few pieces of kidney ore were discovered. Diggings being made, the bed, however, proved to be thin and irregular, being a band in the brown sandstone. Signs of the same seam were met with in other places, in a corresponding position in the strata, but no where gave promise of being productive.

At the mouth of the second fork of Pine creek, the rocks dipping gently to the north, F. IX. extends from the bed of the valley a considerable way up the hills, the conglomerate capping only the highest knobs, and no coal measures appearing above this along Pine creek. The only chance we have of finding them is above the head of Elk run, entering Pine creek a mile and a half above the mouth of the second fork. Here a bed of iron ore was opened a few years ago, below the conglomerate, being probably the same found upon Stony Fork. It was mined for a short distance in by a regular drift, and proved to be between three and four feet in thickness; the whole of which, however, is not ore, a portion consisting of imbedding shale. On Big Pine creek, about four miles above the mouth of the second fork, the rocks, previously nearly horizontal, dip south, bringing in the conglomerate on the summit of the hills, about two miles below this on the east side of the stream. This very shallow basin in the rocks will, therefore, probably not yield any coal along Pine creek.

Retracing our way eastward to the Tioga river, these southern dips are seen to continue from the northern margin of the Blossburg basin, down the stream to a point about midway between Covington and Mansfield. The hills here are low and gently rounded, and consist only of the beds of F. VIII. At Covington, they are capped by F. IX. A band in F. VIII. has been found sufficiently calcareous to yield lime. It is full of fossil shells. North of the flat anticlinal axis between Covington and Mansfield, the northern dips bring in F. X., which caps a belt of higher hills ranging north of the latter town. The dip again changes to the south, about two or three miles north of the mouth of Mile creek, and continues southward as far as the northern boundary of the state. Tracing the anticlinal axis which divides the Blossburg coal measures from the northern unproductive basin, we find it bringing the rocks of F. VIII. to the surface, along the whole belt of country crossing Wilson's creek, Stony Fork, and Big Pine creek, near the Round Island. The gentle depression of the strata to the W. S. W., causes all but the very upper layers of F. VIII. to sink out of view on Pine creek. The calcareous, fossiliferous bands of this formation, occur on Stony Fork, but afford a very indifferent lime. Near the brink of this stream in the alternations of F. VIII. and F. IX. issues a small saline spring, capable of affording a bitter salt. Some years since, an attempt was made to bore for brine at this spot, and the strata were penetrated to the depth of about three hundred feet without procuring and further supply, when the augur broke and the work was given up. The true saliferous rocks of our state are much higher in the series, being the white and porous sandstones of the lower coal measures and of F. XII., and these are never productive in brine, unless when they occur at a considerable depth below the beds of the vallies.

On the Tioga river, the northern dip, carrying down the rocks of F. VIII., forms a broad but shallow basin between Mansfield and the mouth of Mile creek. The Tioga river crosses the bottom of this basin above Tioga village, displaying the rocks of F. IX. Receding from the river, the hills are capped by F. X.; and it has been said that the very highest knobs take in small patches of F. XII. Denudation has, therefore, swept away every remnant of the coal measures which may once have occupied the centre of this trough.

Tracing this northernmost basin westward, we find it crossing Crooked creek, a little north of the Big marsh. The hills bounding it on the north and south being capped by the F. X., the gray slates of F. VIII. appear in the valley between. The town of Wellsborough lies in the latter formation.

About eight miles northwest from the Big Meadows, occurs a bed of iron ore, from which a large deposite of brown ochre has been produced. Much ore has been taken from this spot. The ore band has not been fully developed. It occurs within one hundred feet of the summit of the hill, lying probably below the conglomerate, though that rock does not appear. About two tons only of loose, nodular ore have been excavated. Twenty feet below this bed, a bench or broad terrace occupies the flank of the hill, embracing about twenty acres of surface. It is covered by a rich deposite of the bog ore, to a depth averaging perhaps two feet. Higher on the hill a small seam of coal, one foot in thickness, occurs, which is of limited extent. Near the summit of the hill, are indications of another bed of iron ore.

CHAPTER V.

Sketch of the Geology of that part of Western District of the State which embraces the counties of Armstrong, Clarion, Venango, Butler, Beaver and Mercer.

Though the bituminous coal measures of our state constitute, in strictness but one group of sandstones, limestones, shales and coal seams, not susceptible of any *natural* sub-division, the expediency of adopting some classification of so extensive and complicated a system of rocks, induces me to separate the whole, into an *upper* and *lower series*, and to designate these by the geographical regions which they occupy. The two chief rivers which traverse the basin, flowing in opposite directions, intersect wholly different strata, the Monongahela and its western tributaries passing through the upper coal measures, and the Allegheny through the lower. Starting from the marly shales exposed at the water's edge at Pittsburg, and ascending the former river, we rise into higher and higher layers, and following its western streams into Wayne county, we may even reach the uppermost beds of the whole series. Ascending the latter river on the other hand, we come upon lower and lower rocks, emerging successively to view, until, in the neighborhood of Franklin and Warren, we encounter those that form the bottom of the basin. I propose, therefore, to call the upper coal measures exposed in the valley of the one river, the *Monongahela Series*, and the lower strata, as they are developed in the valley of the other, the *Allegheny Series*. The Monongahela series includes the beds entitled the *Pittsburg Series* in my last annual report.

When the task of tracing the range of the several strata throughout the whole coal basin shall have been completed, and the respective areas of those two divisions of the formation ascertained, the Monongahela series will be found not to extend beyond the limits of Allegheny, Washington and Green counties, the southern townships of Beaver and Armstrong, the south-western ones of Indiana, and all those sections of Westmoreland and Fayette lying north-west of a line near the base of Ches nut Ridge. All other parts of the general coal field situated to the north-west of the Allegheny mountain, are occupied by the Allegheny series to be here described. The boundary between the two series marked by the final outcrop of the shales which are exposed just above the Ohio river at Pittsburg, will not deviate greatly, when ultimately traced, from a line ranging as follows: Commencing at the Ohio river, near the mouth of Yellow creek, and running thence nearly eastward, it crosses the same river again near Economy, and the Allegheny river about the mouth of Bull creek, then deflects a little to the north, passing the Kiskiminitas a few miles above its mouth, and ranging north of Crooked creek, which it also crosses. Assuming a nearly eastern course, it runs north of the town of Indiana, near which it sweeps to the south and south-west, and then follows the base of Ches nut Ridge and west Laurel Hill, to the Maryland line. The country south and west of this boundary is occupied exclusively by the Monongahela series.

COAL MEASURES.—*Allegheny Series.*

Description of the Lower Coal Measures as they occur between Pittsburg and Warren, on both sides of the Allegheny River, adopting the descending order and proceeding Northward.

Having in my last annual report enumerated and described the various beds of the bituminous coal measures of the western counties of the State, which compose that part of the series overlying the lowest stratum exposed at Pittsburg; I propose in the present place to give a similar account of those layers embraced between the same stratum and the sandstones and conglomerate at the bottom of the coal formation. To render this enumeration more intelligible, I shall commence at Pittsburg, in the neighborhood of which the strata are well exposed and familiarly known, and discuss them in the *descending* order as they rise in succession to the level of the Allegheny river between that town and Warren, this being the order of their outcrop from the centre towards the margin of the basin. While specifying the features and composition of each division of the series as it appears adjacent to the Allegheny river, I shall also refer to it in other places, in order to show its range both east and west of that great intersecting valley; but the confined limits of an annual report, and the unfinished state of the geological map, will prevent my attempting to delineate the outcrop of each stratum, or to introduce more than a few localities at which it may be seen. The intelligent reader, *with the Map of the State before him*, will, however, be enabled, it is hoped, with the assistance of these localities and the descriptions given, to trace with sufficient accuracy the range of each important coal bed and other sub-division of the series.

It may be proper in this place to offer some explanatory remarks in reference to the strata exposed on the Allegheny river, between Pittsburg and Freeport; a clear understanding of which will render intelligible to the most cursory observer, the general range and nature of the rocks comprising the northern half of the great western coal basin. The variations in the shales and sandstones present occasionally great difficulties in identifying them. It should be remembered, also, that the divisions of the strata adopted in my reports, though rendered necessary by the nature of the coal measures, are, in fact, more or less arbitrary divisions, which exist with rather less distinctness in nature than might appear from the definite limits assumed for sake of description. Hence, a practical observer, not conversant with geological research, may err in comparing our general accounts with the exposures in some particular neighborhoods.

While the rocks composing the present series are all under the Ohio at Pittsburg, and rise and crop out successively towards the E. the N. E. the N. and N. W., forming an eliptical basin, their dip is by no means regular, but *undulates* considerably, the local inclination differing in a multitude of cases from the general one. Thus, below Freeport, at some of the coal mines, the *local dip* is up the river, while in fact the *general dip* is in the contrary direction, as is shown by the coal cropping out on the north and sinking under the Ohio to the south. The coal vein just described makes its appearance on Pine creek, owing to a local rise in the strata, while it does not show itself above the Allegheny until within a few hundred feet of Tarentum. At Pittsburg it appears to be from one hundred to one hundred and fifty feet below the river, while at Freeport it has the height of one hundred and forty feet above the water. At Kittanning it is still higher, rising further north to the tops of the most elevated hills, and finally cropping out, and occurring, at intermediate points, much lower than a regular dip would carry it.

The variegated shale composing No. 1 of the Monongahela series, is found at the base of all the hills surrounding Pittsburg, and is completely exposed on the river as far as Sharpsburg. Here the hills consist of the same rocks as at Pittsburg, but the shale is higher, causing the Pittsburg coal to be found only on the highest knobs, while the first two strata of the present series begin to show themselves in the lowest places. The sandstones No. 4 and No. 5 of the Monongahela series are here quarried, while the colored shales above them are all well exposed. At Fairview, five miles higher up the river, we find the hills about three hundred and fifty feet high, and too low for the Pittsburg coal; while the colored shales of the Monongahela series compose the upper part of the hills, forming a compact bed one hundred and seventy feet above the water, resting on No. 4 and No. 5 of that series. The bed No. 5 is a compact sandstone, quarried extensively at Alexander's quarry, one mile above, and also at numerous points on the other side of the river. When we arrive at Tarentum, we find that still more of that series has vanished, including the above sandstones. The river hills average two hundred and fifty feet, while the coal, No. 6 of the Allegheny series, has just made its appearance above the canal, with the accompanying strata. At Freeport, the hills are composed almost entirely of the same strata, their denuded summits being in a few instances formed by the colored shales and slaty sandstones of the Monongahela series, while at Kittanning we see at an elevation of one hundred feet the fossiliferous limestone and other rocks which were far beneath the river level at Freeport, and the last remains of the Monongahela series are indicated by the red and variegated shales which cap the high hills on on both sides of the river.

No. 1.—Slaty Argillaceous Sandstone.

Commencing our enumeration of the rocks of the coal measures, with the first bed immediately beneath the red and blue calcareous shale lying at the base of the hills around Pittsburg, we meet with an unimportant and somewhat variable stratum, first well disclosed at the mouth of Cirfies' Run, and Pine Creek. It consists of a light greyish slaty sandstone, generally in thin layers, and usually in a fragmentory condition wherever it has been much exposed. The beds numbered 1, 2, and 3, in the Pittsburg, or Monongahela series, described in my last report, conceal this rock along the river from Pittsburg to Sharpsburg. Beyond the point where it emerges, it is quarried in several places, but is generally too soft to be a useful building stone. It forms the bed and margin of Pine, Deer, Sandy, and Plum creeks, and is also visible on Saw-mill Run, Cirties' and Higby's runs, and in most of the ravines along the river hills between Pittsburg and Tarentum. At Freeport, and in the neighborhood of Kittanning, the true position of this stratum should be on the summits of the very highest hills. From all those of less height, it has been removed by denudation. Gradually thinning out in this direction, it becomes indistinguishable from the inferior strata. Average thickness thirty feet.

No. 2.—*Shale.*

The argillaceous sandstone just described, is seen to be underlaid by a bed of yellow and brown shale, into which it gradually passes, and which indeed is merely the inferior portion of the same deposit. This is exposed along many of the streams and ravines above referred to. We detect it at Freeport, resting upon the thick sandstose which overlies the upper coal seam at that place. Near Kittanning, it occurs on the river hills in contact with the small bed of coal to be next mentioned. Iron ore has not hitherto been noticed in this shale in any quantity. Thickness in considerable.

No. 3.—*Coal.*

A seam of coal, about one foot thick, overlaid by the above shale, shows itself in the river hills fifteen miles above Pittsburg. It is not recognized again until we approach Kittanning, where a band of coal identical with it in position as far as can be ascertained, has been opened near the summits of the hills. At Allegheny furnace, it is two feet thick, but not of sufficient value to lead to its being mined. This seam of coal has been particularized chiefly with a view to prevent persons from confounding it with workable seams situated lower in the series. It ranges westwardly to the vicinity of Butler, where it could probably be detected, were it of sufficient value to justify a minute exploration. It is prolonged, likewise, through the north-west corner of Westmoreland county.

No. 4—*Sandstones and Shale.*

In this division are embraced some beds which are peculiarly interesting, as they produce a marked influence upon the physical features of the district where they appear. Their variable character tends at the same time, not a little to embarrass the geological inquirer. While the coal seam, and beds of limestone, are traceable with comparatively little modification of aspect or composition, over an extensive range, these intrinsically less useful strata, are much less easily followed. Being more or less irregular accumulations of sand and clay somewhat promiscuously deposited by conflicting currents, a considerable diversity of composition, is apparent wherever we compare them at distant points. Throughout the coal measures generally, the sandstones vary in appearance, when traced sometimes only a few feet, and often thin out entirely in the distance of a few miles, beds of shale, totally different in their nature replacing them.

Overlying the upper coal seam on the Allegheny river below Freeport, we find a thick bed of sandstone, consisting of two layers, each averaging thirty-five feet in thickness, and separated by about twenty five feet of shale. The sandstone is remarkably coarse, and very compact and heavy. It assumes, in many places, the aspect of a true conglomerate, particularly in the lower layers of the upper stratum, where a band about four feet in depth consists of round water-worn pebbles of white quartz. Imbedded in this rock, are nodules of iron ore, varying from one to six inches in diameter. Immediately beneath this, we not unfrequently find about six inches of coal interstratified with slate. The lower sandstone divided from the upper by shale, and thinly bedded slaty sandstone, is of similar character, This rock in many places, affords a good building stone, and may readily be quarried.

From Tarentum to Freeport, the whole tripple mass of sandstones and shales, forms a conspicuous stratum along the river hills, gradually ascending, until it reaches their summits above the mouth of the Kiskiminitas. It forms a belt of high hills, extending north east and south-west through Buffalo township, Armstrong county. These rocks change their character materially in the vicinity of Kittaning: becoming one general stratum of slaty sandstones, with layers of interposed shale in place of two well marked beds of pure sandstone, divided by a thick belt of argillaceous shale. Spreading northward on both sides of the river, it occurs near the summits of the hills, almost as far up as the mouth of Red Bank creek, where the heights become too low to receive it.

The stratum can be traced stretching east and west from the Allegheny river, in common with the other adjacent members of the series until it crops out on the highest grounds and disappears. It is exposed on the Kiskiminitas, and also extensively throughout the eastern part of Armstrong county. In Butler county it forms the principal portion of the elevated land lying between Buffalo creek on the east, and Slippery Rock creek and its branches on the west. The hills north of the town of Butler contain it, but the stratum here is less compact than in many other situations. It extends generally through Centre, Butler, and Middlesex townships, and parts of Muddy Creek, Slippery Rock, Parker and Donegal townships, forming high hills, covered with a stunted growth of scrub oaks and other trees. A belt of naked or glade-like hills, extending from near Porterville in a north-east direction, through Slippery Rock and Parker towships, designates its northern outcrop. Removed by denudation from the lower grounds bordering Slippery Rock creek, the stratum again appears on the western side of Mercer county. Average thickness, seventy-five feet.

No. 5—Shale.

Beneath the stratum just described, and reposing upon a bed of coal, next to be mentioned, is a thick mass of brown and blackish shales, sometimes laminated, but generally very friable, and containing, like nearly all the shales of the series, more or less nodular iron ore.

Below Freeport, where the massive sandstones overlie the coal it varies from two to twenty feet in thickness; but at Kittaning it is much thicker, and in the neighborhood of Butler it measures more than fifty feet.

No. 6—Coal.

We come now to the first workable coal seam of the Allegheny series, and one of the most important and widely extended beneath the Pittsburg and Monongahela group. This bed affords a remarkably rich, compact and inflammable coal. It has been found by trial, to make an excellent coke. Different portions of the bed vary, of course, in the quality of the coal; some bands containing more or less slate and sulphuret of iron. By a little skill, this seam will be found to furnish, it is believed, in many places, a fuel equal to that derived from the main Pittsburg bed.

As the strata emerging from below the water at Pittsburg, exhibit a gently undulating and not perfectly regular dip, this bed rises about three miles below Tarentum, near which it is mined at an elevation of thirty feet, though it shows itself on Pine creek, about two and a-half miles from the river, on the land of Mr. Shaw, and others, exactly on a level with the stream. It is here six feet thick. At Peterson's salt well, one mile below Tarentum, it is of the same thickness, being opened beneath a bed of shale, at an elevation twenty-five feet higher than it occurs only half a mile further down the river, showing a gradual but irregular ascent as we trace it towards the north. At Kier's salt well, a short distance above, it is seven feet thick, and is mined forty feet above the level of the river. At Tarentum it is opened at Donnelly's salt well, and in several other places on both banks of the river, within three miles of which it is also mined on Bull creek. At Freeport this valuable coal seam lies, by measurement, one hundred and forty-four feet above the water. It here supplies Weaver's, Lowery's, Donnelly's and other salt wells. In this vicinity its average thickness is four feet, and its dip is to the S. S. W. at an inclination of about fifteen feet to the mile.

On the Kiskiminitas this seam of coal supplies fuel to a number of salt works. At Kittanning we find it at the height of three hundred and seventy feet above the river, being opened both on the east bank and at Allegheny furnace. It occurs on Mahoning and Red Bank creeks, and is well exposed at the mouth of Sugar creek, where it occupies only the summits of the higher river hills, many of which are too low to embrace it. This is not far from its northern outcrop, no trace of it occurring along the Allegheny, above the mouth of Bear creek.

This coal seam has been carefully traced through the eastern part of Armstrong county. It is opened more extensively in Allegheny, Pine, Wayne and Red Bank townships, than elsewhere. Tracing it from the river hills, from many of which it has been removed by denudation, it ranges westward through the central parts of Butler county, and through portions of Allegheny and Beaver counties, disappearing ultimately beneath the Ohio river, in conformity with the general south-western dip of the coal measures. Near the town of Butler, where it is extensively wrought, it holds a high position in the hills. It is here four feet in thickness. It occupies a lower level on the lands of Alexander Boyd, in the north-west corner of Middlesex township, half a mile east of the township line. The general surface of the country throughout Mercer, Venango, and part of Slippery Rock townships, in this county, is not sufficiently elevated to embrace this number of the series :-the fossiliferous limestone, presently to be described, constituting one of the upper rocks, throughout this district.

Ascending the Kiskiminitas, this stratum of coal is wrought in many places until it is hid below the level of the valley.

No. 7.—Non-Fossiliferous Limestone.

Supporting the above coal seam, is a bed of limestone, the true position of which is a few feet below the coal, separated from it by a soft shale, and sometimes by a hard, black, bituminous slate, containing vegetable impressions. Below Freeport, where this stratum first emerges from beneath the level of the streams, it consists not of a compact bed of limestone, but of loose nodular masses of that rock, irregularly imbedded in shale. These are very hard and fine grained, and of a light blue color, and conchoidal fracture, affording a strong but ash colored lime. Proceeding towards the north and east, the bed acquires greater compactness, and becomes valuable as a source of fertility to the soil, upon which, unfortunately, lime is not sufficiently employed.

This limestone bed occurs at the hills near Kittanning, and also on those around Red Bank and Mahoning creeks. At the mouth of Sugar creek it occupies the summits of the river hills, where it is overlaid by the coal seam, No. 6, separated from it by a calcareous shale three feet in thickness. The stratum is here four feet thick, excessively hard, of a dark blue color, and very pure. Throughout the eastern part of Armstrong county, it is traceable from the Kiskiminitas to the north side of Red Bank creek, becoming a peculiarly solid and compact bed, in Pine, Wayne, and Red Bank townships. About one mile south of Mahoning, it is opened on the farm of Mr. Peter Lais. Near the village of New Bethlehem, it shows itself on the lands of Messrs. Henry Doverspike, Thomas M'Kelvy, and others, being a hard, dark blue rock, containing only a few fossils.

Westward from the Allegheny river, it ranges in common with the overlying coal through the central parts of Butler county, cropping out on the north and west. It was discovered by us at the town of Butler, where, strange to say, it has not been wrought. It is from this stratum that the central townships of Butler county will be supplied with lime, as soon as the importance of calcareous manure shall be duly appreciated. Here its value is enhanced by the argillaceous, ferruginous character of the soil, rendering lime especially beneficial. Through a remarkable oversight, the existence of this stratum is hardly known to the inhabitants who derive their chief supply of lime from a bed of inferior quality, No. 15, of the series, hauling it a considerable distance. It undoubtedly extends through Middlesex, Butler and Centre townships, and parts of Cranberry, Muddy creek, and Parker townships, in the latter of which, it is opened near the village of Fairview. Its proximity to the coal will not only facilitate its convertion into lime, but readily lead to its discovery, its proper situation being under the coal seam, No. 6, of the series, either in contact with it, or separated by a few feet of soft shale. It does not always occur as a compact bed, but assumes this condition as we approach its outcrop, agreeing, in this particular, with the overlying coal.

This limestone should not be confounded with the fossiliferous limestone, to be hereafter described, which, entering the river hills below Kittanning, shows itself on Buffalo creek, passes under the table land of Butler, and ultimately re-appears on Muddy creek and Slippery Rock. That limestone must lie at least two hundred feet below the level of the Conequenessing, at the town of Butler. The bed before us is distinguished from it, by rarely containing any *fossils*, although these occasionally occur in the brown calcareous shales which divide it from the overlying coal. We ought to mention that its surface frequently presents blotches of a different tint from that of the surrounding parts of the rock. These may readily be mistaken, by the inexperienced observer, for minute fossils. Thickness from three to six feet.

No. 8.—*Sla'y Sandstone and Shale.*

Underlying the limestone, we usually find a bed of sandstone interstratified with shale, but varying much in composition. The sandstone occurs in layers from six to twelve inches thick—sometimes in contact, sometimes separated from each other by shale. This latter is generally brown, and often breaks into thin splints. In other instances it is compact, and contains a considerable quantity of nodular iron ore. At Freeport, the stratum is fifty-one feet thick; at Kittanning, forty-two feet. Average thickness about fifty feet.

No. 9.—*Coal.*

The next bed in the descending order is a seam of coal. This is remarkably variable. It appears above the level of the Allegheny river, about two miles above Tarentum, and is wrought at Morrison's salt-well, where it affords a good fuel. The bed is remarkably irregular as regards thickness, measuring in some places four feet; in other places only two feet. We may trace it from this point to the mouth of the Kiskiminitas, where a thin layer of soft bituminous shale, mixed with coal, supplies its place. A similar condition of things exists at Leechburg. This coal seam, at Freeport, lies at an elevation of fifty-seven feet above the level of the river, and at a considerably greater height at Kittanning. A bed of coal, believed to be the same, appears on the Conequenessing creek, near the village of Harmony, where it is opened on the land of Jacob Ziegler. It is here of good quality, varying in thickness from two and a-half to three feet. It is also opened at Zelienople. This coal is remarkable for its irregularity, not only as respects its thickness and local dip, but as regards the nature of the accompanying strata.

No. 10.—*Sandstone.*

Beneath the above coal—sometimes in contact with it, sometimes separated by soft shale—occurs a thick bed of sandstone. This is remarkable for its variable dip and composition, the layers being often curiously contorted, apparently from their irregular mode of deposition. It contains numerous vegetable impressions. Along the Kiskiminitas, between Leechburg and Freeport, it is well exposed, occurring as a coarse grained compact gray and brownish sandstone. The vegetable impressions are frequently beautiful, belonging to the genera *Sigillaria*, *Lepidodendron*, *Calamites*, &c., the first existing in great abundance. This stratum seems to have been deposited by a rather turbulent current, if we may judge from the oblique and irregular disposition of the layers. These are often separated by thin bands of shale, and sometimes by seams of coal from six inches to two feet thick, which frequently thin out in the space of ten or twenty yards. The brown variety crumbles by exposure into a ferruginous sand.—Persons in quest of coal should avoid confounding the numerous bands in this stratum, with the more regular seams of the series from which they differ in being never continuous, ending sometimes very abrubtly. Thickness seventy feet.

No. 11—*Shale.*

Between the preceding sandstone and the coal next to be described, occurs an important stratum of dark shale, containing fireclay and nodular iron ore. Some layers are soft and carbonaceous, resembling at their outcrop a coal smut; others are friable, breaking into narrow, longitudinal fragments. In some places it embraces layers of slaty sandstone, also fireclay of good quality. Near the middle of the mass are two bands of coal, requiring particular notice. The first of these is one foot thick, the other varies from one foot to eighteen inches in thickness. As we have not found these to be continuous over any great space, and as they are too thin to be profitably worked, we have not deemed it expedient to describe them as separate seams. In some localities, the laminæ of the shale are remarkably regular, and it may be procured in large plates; other portions contain much sulphuret of iron, and readily crumble by exposure. The iron ore of this stratum is usually in slabs, irregularly scattered through the shale, but most abundant above the underlying coal.

This member of the series deserves especial attention, as it probably contains, in some situations, seams of coal worth pursuing, besides valuable deposits of iron ore and fireclay. Thickness from 75 to 100 feet.

No. 12—*Coal.*

Immediately underlying the above stratum, is a widely extended and important seam of coal, emerging from below the Allegheny river, about five miles above the mouth of the Kiskiminitas. At Kittaning it attains an elevation of six feet, being extensively wrought near the base of the hills, on both sides of the river. It is 3½ feet thick. At its outcrop the coal is often inferior, but further in the hill, it affords an excellent fuel. Like all the other seams, it varies somewhat in thickness, and contains irregular nodules of sulphuret of iron. Many of the salt wells in the vicinity are supplied with fuel from this bed.

This coal seam may be readily traced on the river hills, between Kittaning and the mouth of the Clarion river. On each side of the Allegheny, we find it heading in the small streams and brooks which empty into the river. It finally sinks beneath the water level of the country, towards the south-west, to re-appear on the Beaver river and its branches. Its position above the fossiliferous limestone, to be described presently, enables us to trace it with facility and precision. Eastward of the Allegheny river, it shows itself on the Cowanshannock creek and on Crooked creek, ranging to within a short distance of the county line of Indiana, and likewise on Red Bank Creek, where it reaches to about the same distance from the Jefferson county line. Disappearing beneath the hills which form the west slope of the Allegheny river at Kittaning, it re-appears on Buffalo creek, where it is worked at Horner's Mills. Thence it passes under the high grounds in the centre of Butler county, and reaches the day once more on the Slippery Rock and other streams, towards the west. This seam is mined on the Neshannock creek.

In consequence of the changeful thickness of the shale, interposed between this coal bed and the fossiliferous limestone beneath, it sometimes rests almost in contact with the latter, though the usual thickness of the shale is from twenty-five to thirty-five feet. Considering the great extent of country occupied by these strata, and the manner in which they were deposited, some from quiet waters, some from turbulent currents, it should not surprise us that they thus vary in thickness and composition. Their position in the series, however, is constant, and a careful examination will almost invariably enable us to trace them. Thickness of the coal, from three to five feet.

On the south side of the Red Bank creek, in Red Bank township, Armstrong county, a deposite of *cannel coal* has been opened on the lands of Mr. Alexander Cathcart. Here we find a bed of common *bituminous coal* two feet thick, supporting one of *cannel coal* eight feet six inches in thickness. The latter is light, compact, of a dull lustre, and a conchoidal fracture, and belongs to the variety denominated slaty cannel coal. It ignites with facility, burning with a bright flame, and leaving but a moderate amount of ashes. It forms a compact bed not regularly laminated, and is distinctly separated from the coal beneath. From all the evidence we could collect, without resorting to extensive digging, we conceive this coal seam to be the same with that above described. The cannel coal is not traceable beyond this neighborhood, being merely a local modification of the deposite, the remarkably bituminous roof of the bed passing into cannel coal.

Three miles from Greensburg, Beaver county, there occurs a very analogous bed of cannel coal, resting on ordinary bituminous coal.—The whole seam there is eleven feet in thickness.

No. 13.—*Shale.*

Below the coal just described is a bed of brown and black shale, with interposed layers of sandstone. This is an important repository of nodular *iron ore*, always containing that mineral in greater or less abundance. The ore is generally greatest in amount directly under the above mentioned coal seam, where the shale is soft and friable.—In Clarion county, and the southern part of Venango, where this stratum not unfrequently caps the hills, covering the limestone to be described, we find it to contain large quantities of blue nodular iron ore. Both in Venango and Mercer counties, the centre of the stratum is sometimes occupied by a bed of solid sandstone, occasionally ten feet in thickness. It is worthy of remark, that the iron ore abounds in proportion to the deficiency of these sandstone layers in the stratum. Average thickness twenty-five feet.

No. 14.—*Buhr-Stone, and Brown Siliceous Iron Ore.*

Between the shale above spoken of, and a limestone to be next described, occurs a siliceous and ferruginous deposite of great economical importance, and of singular character. When not largely impregnated with the oxide of iron, this bed constitutes a hard greyish and yellowish chert, or flint, of a somewhat cellular structure. Some portions are precisely analogous, both in composition and appearance, to the burr-stone of France. When it is much charged with the oxide of iron, with which it is in contact, the weathered specimens exhibit a worm-eaten or cavernous appearance, arising not merely from the removal of the oxide of iron lodged in it, but from the dissolution of the calcareous matter derived from the adjacent limestone. The open cellular variety is usually white or yellowish; the compact kind black, bluish, and brown. The bed is sometimes fossiliferous, containing *encrini*, and other organic remains.

Reposing directly upon the siliceous rock and passing into it, there is a highly important bed of iron ore, which has already become of great value to the counties bordering the Allegheny river, and which is destined to occupy a still more conspicuous place among the mineral treasures of our great bituminous coal field, when its true geological relations shall be understood, and its productiveness appreciated. This ore consists generally of a mixure of the peroxide and protocarbonate of iron, the latter predominating, except near the outcrop. At its outcrop it is composed almost exclusively of the brown hydrated peroxide, and is of various tints of brown and red. Its structure is often cellular, the irregular cavities being surrounded by a thinner or thicker crust of the ore. In other instances, it occurs in large masses, in which the ore is intimately mingled with the chert, and is full of drusy cavities, lined with minute chrystals of quartz, tinged red, brown, and pink, by the oxide of iron. These cavities sometimes contain water. Though this seam of ore follows the limestone over considerable spaces of country, it is not strictly continuous, but occurs rather in large patches of various thickness. The buhr-stone and the iron ore would seem indeed mutually to replace each other, the one most abounding where the other is deficient. For the chemical composition of this ore, see the *analyses*, Chap. VI.

Where the fossiliferous limestone emerges from beneath the level of the Allegheny river, a few miles above the mouth of the Kiskiminitas, the ore and buhr-stone are not discoverable. They occur, however, at the furnace of Mr. M'Nichols, 2½ miles above Kittanning.—Here the ore overlies the limestone, in a band which in some places is two feet nine inches thick. The upper layers of the limestone are impregnated with more or less of the ore. This rock is of a buff color at its outcrop, effervescing freely when touched with an acid, and being full of various fossils. The buhr-stone or siliceous stratum, is found in detached beds, from six to eight yards in area, overlying the limestone. It is here a yellowish white flint.

Proceeding northward from this neighborhood, we have traced this ore in the river hills, between Red Bank and Mahoning creeks. The buhr-stone was also observed, overlying the fossiliferous limestone, at the mounth of Sugar creek, and also at the mouth of Bear creek, in the vicinity of Lawrenceburg. Eastward of the Allegheny river, the ore extends through Clarion county, the limestone rising to the surface of the country. This ferruginous bed, connected with the buhr-stone, supplies ore to Mill Creek, Webster, Beaver, Shippenville, Lucinda, Madison, and Clarion furnaces, in this county, and to Etna and Jackson furnaces, in Butler county. In Richland township, Clarion county, it is mined on the land of Mr. M'Ginnis. The ore here rests in immediate contact with the buhr-stone and limestone.—Its average thickness is fifteen inches, but in some places it is three feet. Between the ore and limestone, their often occur large cavities, some of which are several yards in extent, and from twelve to twenty inches deep. These seem to have been formed by the removal of the shale and other strata, by the gradual infiltration of the water from above. The overlying shale both here and in many other localities, has been converted into a tough clay, in which the lumps of siliceous ore are imbedded.

The ore has been opened on the land of Mr. John Allsbach, in this neighborhood. The bed is there nine inches in thickness, and is partially interstratified with the flint, which occasionally renders it two siliceous to be profitably smelted. The rock breaks into large cuboidal masses of a grey, blue and yellow color, having spots and little seams of brown iron ore. These masses are occasionally much weather-eaten from the disintegration of the calcareous and softer portions. The overlying bed of ore varies from nine to eighteen inches in thickness.

About two miles south of Shippenville, the ore is mined at the "deal bank," belonging to Messrs. Shippen and Black, and to Myers & Co. The thickness of the ore averages two feet. It is a compact stratum, overlaid by blue shale and slaty sandstone. It is opened on the land of Blackstone, Long & Co., in the same neighborhood where it has a similar structure, though its thickness is unusually great. It here occurs in a solid bed about five feet in thickness, in one place becoming nine feet thick. It has an imperfectly cellular structure, and contains drusy cavities, some of which are filled with water. The material of the buhr-stone mingles itself in small quantities with the ore, and indeed the whole deposit is remarkably siliceous.

In Elk township, about a mile and a-half south of the turnpike, the ore is exposed on the lands of William Allsbach, Joseph Kutcher and others. At Kutcher's bank the bed varies from one to two and a-half feet in thickness. It is here chiefly of the spathose variety, being a semi-crystalline protocarbonate, of a grey and somewhat metallic aspect, and very heavy and compact. It breaks into large masses, consisting of the protocarbonate, surrounded by a crust of the peroxide, of a deep red color, which is usually an inch or more in thickness. One mile north of this locality, the limestone crops out on the surface of the ground, exhibiting itself in white and yellowish masses generally two or three feet in length.

The buhr-stone ore is wrought at Lucinda furnace, about eight miles north of Shippenville, and also in Pinegrove township, on the land of Mr. Henly, and others. At the former place it overlies the limestone, and varies in thickness from six to twenty-four inches. In some places the ore is replaced by the flint or buhr-stone. Much of it is of the cellular variety, the drusy cavities being often coated with a beautiful glaze, such as we behold in the hollow balls of ore found above the limestone, F. II. in the valleys of the Appalachian region of the State.

On the western side of the Clarion, in Paint creek township, the ore and buhr-stone are well exposed on the lands of Samuel Thomas, Daniel M'Naughton, and others. In the country south-east of that stream, the ore is exposed in many localities, and can be traced to the Jefferson county line. Its eastern and northern outcrop is governed by that of the limestone which it accompanies. Following it to the south-west we find it, after it passes under the river hill at Kittanning reappearing on Buffalo creek, and there burying itself beneath the high grounds in the central parts of Butler county, to emerge again in Muddy creek, Slippery Rock, and Mercer townships. It is opened on the land of Judge Bouvard, four miles east of Centreville, where the bed is from six to twenty inces thick, the buhr-stone occasionally replacing the ore, and forming a bed which is here sometimes one foot thick, resting upon the limestone. The ore is wrought on the land of Mr. Buchanan, about two miles north of the above locality, where it and the buhr-stone are seen overlying the limestone. The ore is of excellent quality, and averages nine inches in thickness.

The great importance of this valuable deposit to the growing wealth and enterprise of the western part of the State, is beginning to be appreciated. I need hardly, therefore, dwell upon it any further than to mention the following circumstances in its favor. The richness of this ore, far exceeding that of the nodular variety common in the slates of the coal measures, will bear comparison with much of the best ore found in the limestone valleys south-east of the Allegheny mountain. Another merit is the facility with which it may be smelted either alone or when mixed with the nodular or ball ore; and particularly with the bog ore found so abundantly in Venango and Clarion counties. In the thicker parts of the deposit, it is a nearly pure semi crystalline protocarbonate of iron, a variety well known to be susceptible of extremely easy reduction. It is moreover recommended by the readiness with which it can be traced, arising from its accompanying closely the fossiliferous limestone, which furnishes an excellent landmark. The buhr-stone assists the discovery of it in a still greater degree, the fragments of that peculiar stone being so easily recognized, serving to point out the position of the ore. Besides these important facts, it should be mentioned that a workable seam of coal occurs above the ore and limestone, and another beneath them at a moderate interval. The importance of this tripple association of the materials employed in the manufacture of iron, to the future wealth of our western counties must be obvious to every one who adverts to the incalculable advantage which Great Britain has derived from the same fortunate union.

No. 15.—*Fossiliferous Limestone.*

The stratum which next succeeds the buhr-stone in the descending order, is a compact bed of light blue limestone. Its upper layers are occasionally tinged yellow by the ferruginous infiltration from the overlying stratum. In other instances, the weathered surfaces are of a dark grey color. The limestone in certain localities is remarkably slaty, consisting of thin shivery layers. This peculiar aspect arises in part from its sandy composition, which impairs its cohesion. When it is of this kind, much care is requisite in converting it into lime, lest too intense a heat should vitrify it. Properly calcined it yields an excellent gray lime. It abounds in fossils, particularly of the genus *encrinite*, the round seams of which stand out from the weathered surfaces of the rock. They are generally composed of crystalized rhombic carbonate of lime; and the characteristic fossil is a small species of *terebratula*, which in some places seems to constitute a large proportion of the rock. The teeth and other remains of *sancoid fishes* also exist in this stratum.

The limestone rises above the level of the Allegheny river, about four miles above the mouth of the Kiskiminitas. At this latter place it has been passed at the depth of one hundred feet in boring a salt well. At Kittanning it attains an elevation of one hundred and four feet above the river, being here ten feet in thickness. East of the river it is exposed along many of the tributary streams, particularly Crooked creek, where it measures seven feet in thickness. We find it on Red Bank creek, east of the village of New Bethlehem, and also well exposed on the land of Mr. Joseph Smith, where it lies near the water, in a bed ten feet thick. It re-appears west of Kittanning on Buffalo creek, and on Rough river, forming a conspicuous stratum fifteen feet in thickness.

Gradually rising as we advance up the Allegheny river, the limestone shows itself on the hills of Sugar creek, and is seen at the mouth of Bear creek at a height of several hundred feet above the water, capping the summits. From this point it stretches to the north-east, being traceable on both sides of Clarion river, until it reaches the western line of Jefferson county, beyond which we have not yet pursued it. Some striking and peculiar features mark the northern outcrop of this limestone, especially near the line of the northern turnpike. Rising with a gentle elevation from the south-west, it forms a series of insulated knobs, usually covered with a growth of chestnut and other deciduous trees, which contrast strongly with the surrounding evergreen foliage of the pine and hemlock. The position of the limestone in these knobs is plainly indicated, even to the eye of a superficial observer, by a little bench or terrace, caused by the washing away of the soft and underlying strata. These limestone knobs are numerous in Pine Grove, Elk Creek and Irvine townships, in Venango county. On the western side of the Allegheny river, the northern outcrop of the stratum is still more distinctly defined. It approaches within ten miles of Franklin, where it is exposed on the farm of Mr. Boner. It shows itself on Sugar creek, Bear creek and Buffalo creek, at a small elevation above these streams, westward of which it disappears under the hills of Butler county, coming again to the surface on Muddy creek and Slippery Rock. Near the former stream it may be seen on the lands of Mr. Jonathan Wriner, where it is accompanied by the buhr-stone, and is fifteen feet in thickness.

Slippery Rock and Mercer townships, in Butler county, being much lower than the township south of them, present a surface formed of this limestone and the strata which immediately overlie it. The bed is wrought in the neighborhood of Centreville and Harrisville, where it forms a series of low, flat ridges, similar in outline and structure to the hills which mark its outcrop in Clarion county. Rising gradually from the north-west corner of Butler county, it extends to the centre of Mercer, its northern outcrop being traceable from the vicinity of Sandy lake, in a south-west direction, passing west of the town of Mercer, and thence onward until it reaches the State of Ohio.

This bed of limestone is exposed on the land of Mr. Porter, one mile from the town of Mercer, where it is between two and three feet thick, and rests directly in contact with an underlying seam of coal, which in other places is usually separated from it by a bed of shale. This locality is near the north-western limit of the stratum, which seems to thin out and disappear as we follow it towards the north-west. The rock is here slaty in its upper layers, and darker and heavier than usual. It has this same aspect at Sandy lake, ten miles N. N. E. of Mercer, on the margin of which the limestone is exposed in a dark and slaty seam, only fifteen inches thick, having a bituminous odor and abounding in fossils. It is overlaid by two seams of coal which have been opened. The upper one is five feet in thickness.

Three miles above New Castle, the limestone is exposed on the farms of Mr. Carpenter and others, where it occurs at a considerable elevation above the Neshannock. It is here a dark blue, very compact and fossiliferous rock, about ten feet in thickness. The stratum is again visible on the hills which overlook the Beaver river, about nine miles below New Castle, where it is ten feet in thickness, and has the singular shrivelled aspect which it present on Crooked creek, in Armstrong county. It is also exposed at various other places in this vicinity. Descending the Beaver we may trace it finally to the Ohio river, where it is well exposed two miles below the borough of Beaver, in the form of a dark blue, fossiliferous stratum, twenty feet thick, which dips gently to the south-west. It here occurs at the base of the hills at a small elevation above the river, beneath which it finally disappears.

The wide range of this stratum, its value as a source of pure lime, and its importance as a guide to the overlying buhr-stone ore, are too obvious to require comment here. Its exact position may be readily ascertained by the inhabitants of the wide district over which it spreads, in almost every spot where it lies above the general water level of the country. It is only necessary to attend to the dimension or thickness of the strata here laid down, to identify some well characterized member of the series, and then to institute a simple measurement by a levelling instrument, giving the heighth or depth of the ascertained stratum, and we can infer with sufficient accuracy the situation at any place, both of this limestone and every other bed in the group. There are numberless points on both sides of the ravines, where the outcrop of the limestone is concealed by a slight covering of earth, where it could readily be detected if the farmer had a correct notion, such as the present report is intended to convey, of the true relative position of the strata, and their general range and dip. A little knowledge respecting the true place in the series of this limestone, will prove an invaluable guide to the coal, several seams of which occur near it, in situations readily ascertained by calculation from the thickness here furnished. The average thickness of the limestone may be stated at fifteen feet.

No. 16. Shale.

Beneath the limestone rests a bed of shale of great importance, in an economical point of view, as it is the depository of a considerable amount of nodular *iron ore.* It has the usual aspect of the shale of the coal measures, and like nearly all of them, is occasionally replaced by layers of argillaceous sandstone. In such cases, the stratum acquires twice its usual thickness, becoming a mass of alternating layers of shale and slaty sandstone, separating the limestone from the underlying seam of coal. Tracing it in connection with the other members of the series, we find it well exposed at Allegheny furnace, two and a-half miles above Kittanning. It here embraces nine layers of nodules of the ore, in a thickness of twelve feet. These nodules vary in diameter from six to twelve inches. They are flattish, and of a lemellar structure. Ore of good quality occurs in this shale at various other places in the same section of country.

Ascending the Allegheny river, we meet with many localities where this stratum presents indications of the ore. Near Scrubgrass and Rockland furnaces, the ore is extensively worked. This shale merits indeed an attentive examination on the part of those interested in the development of iron ore. In many places the rock is between thirty and forty feet thick, when it contains much slaty sandstone. In the southern part of Venango county, especially in Irwine and Rockland townships, it does not exceed ten feet. The lower layers in contact with the coal, often contain vegetable impressions. The average thickness of the mass is twenty feet.

No. 17. Coal.

Underlying the preceding stratum, there occurs a vein of coal extending over a considerable tract of country. We find it slowly rising above the base of the river hills, above Kittanning, until it attains an elevation of several hundred feet near the mouth of Bear creek. It has been here mined to a small extent on the land of Mr. R. Leonard, the seam being three and a-half feet thick, and affording an excellent coal for fuel; under it there lies a bed of fire-clay, three feet in thickness. At Robinson's salt wells, eight miles lower down the Allegheny, this coal seam is worked to the height of two hundred and thirty-three feet above the river. East of the Allegheny and south of the Clarion, it is opened in many places. At the mouth of Schull's run, it crops out along the brow of the river hills at a still geater elevation than that above recorded. On the opposite side of the Allegheny, it is well exposed on the lands of Mr. Crawford and others. There is a seam of coal five feet in thickness opened in this neighborhood, on the lands of Mr. Coe and others, which, as far as we have yet been able to determine, is the same bed as that now described. Over it lie three thinner layers of coal, each less than a foot in thickness, separated from each other by shale.

The coal bed we have been tracing, ranges through Irwine and Sandy creek townships, Venango county, where it is worked on the lands of Messrs. Wm. Cross, Joseph M'Kean ——— Boner and others. It here lies about twelve feet below the limestone. Rejecting a band of coal twenty inches thick, embraced in the overlying shale, the principal seam measures three and a-half feet in thickness. It can be traced east of the river throughout Venango and Clarion counties, as far as the boundary line of the latter, beyond which no examination has yet been made. It is well exposed in many places in Pine Grove and Farmington townships, as at Lucinda furnace, where it occurs about thirty feet below the limestone.

This seam of coal, in common with many other members of the series, appear to thin away towards the north-west as it approaches its outcrop, for in the vicinity of the town of Mercer we find it lying immediately below the limestone, and only three feet thick. At the north of Beaver river, there occurs a bed of coal near the level of the Ohio, the position of which, in relation to the overlying fossiliferous limestone, is identical with that of the present seam. Traced to the south-west, it sinks beneath the bed of the Ohio, in conformity with the general dip of all the coal measures in this neighborhood. The average thickness of this coal seam is four feet.

No. 18—*Shale and Argillaceous Sandstone.*

Immediately under the coal just described we find a bed of shale, sometimes passing gradually into a slaty argillaceous sandstone. The upper layers near the base of the coal frequently contain nodules of *iron ore*, which are sometimes from two to three feet in length, and of excellent quality. These seem to lie irregularly in the shale; the smaller nodules are more homogeneous in composition, compact and fine grained. Sometimes, however, they contain much sulphuret of iron and calcareous spar. The larger masses include generally an oblong somewhat cylindrical nucleus, which near the outcrop is surrounded by a concentric crust of peroxide of iron, of various degrees of fineness. This outer shell readily crumbles by exposure. Closely examined, these large nodules present a distinctly oolitic structure. Though of a coarse grain, derived from a large amount of earthy ingredients, they are freer from sulphur than the smaller and more compact nodules. The shale in which the ore most abounds, is of a yellow color, soft and friable, and belongs to the first eight feet below the coal.

In the lower layers of the general stratum, we sometimes find thin bands of coal and black bituminous shale, varying from three to ten inches in thickness. Care should be observed not to confound these with the regular continuous coal seams which we have enumerated as separate members of the series. Good iron ore is obtained from the present stratum, in the vicinity of Rockland furnace, in Rockland township, Venango county.

When the sandstone layers increase in quantity and thickness, the iron ore becomes proportionately deficient. Separating the layers of sandstone, occur sometimes bands of soft bituminous shale, which resemble coal smut, and which frequently mislead the explorer after coal. The upper half of the stratum passes by decomposition into a bed of clay, showing but few traces of the original lamination of the shale. This contains some nodules of iron ore. The average thickness of the whole stratum is about forty feet.

No. 19. *Coal.*

Succeeding the above deposit of shale and sandstone, there occurs another seam of coal which we have traced over a considerable range of country. 'As its outcrop extends in a north-east and south-west direction through Mercer, Venango and Clarion counties, traversing a country where the rocks are much concealed by forest, we find the bed but very partially exposed. Its position, at a moderate depth below the limestone, greatly facilitates its detection. It will prove a valuabled bed whenever the district which it occupies shall become thickly settled. It is the lowest workable coal seam hitherto found in the series along the Allegheny river, for, though numerous thin bands of coal occur in the slate beneath it, we have yet found more of them of sufficient size to merit a distinct enumeration. This layer of coal is opened on the farm of Mr. Joseph Brandon, six miles east of Franklin, where it lies on the summits of the hills beneath the black bituminous shale. It here measures twenty inches in thickness, and is a kind of semi-cannel coal, light, of a slaty structure, and of a peculiar lustre. It somewhat resembles a soft black slate, but is a tolerably pure coal, burning freely, with considerable flame.

It is opened on the lands of Messrs. John W. How and E. Bratton in Rockland township, where it occupies the river hills. Here the layers succeed each other as follows:

Brown shale with ore, ...	8 feet	
Coal, ...		4 inches.
Black shale, ...	1 "	
Coal, ...		3 "
Black shale, ...	3 "	
Coal, ...		18 "

The coal ignates readily, and resembles that above described. It lies several hundred feet above the river. This seam may be traced on the opposite side of the Allegheny, in Irwine township, Venango county, being opened on the land of Judge M'Kee, where it is about two feet in thickness, and rests on the bituminous shale. Thickness two feet.

FORMATION XII. *White Sandstone*

We have now arrived at the coarse and massive sandstone which constitutes the bottom of the productive coal measures, and which exercises a marked influence in the topography of the country.—Emerging from the level of the Allegheny river, above Kittanning, this stratum rises to a considerable height above the water, near the mouth of the Clarion, though it is covered by the overlying coal measures. In the neighborhood of Franklin, however, it caps the hills on both sides of the river, and forms the general surface of the country throughout the northern part of Venango.

In this section of the State, F. XII. is of a fine grained sandstone, consisting of minute rounded grains of quartz. Its prevailing color is a whitish gray, though it is often streaked and blotched with brown peroxide of iron. Where it is much exposed to the weather, it disintegrates into sand, the ferruginous matter being removed by solution. The whole mass consists usually of two solid beds of sandstone, the upper about fifteen feet, the lower about thirty feet in thickness. These are separated by layers of shale and slaty sandstone, variously alternating, which contain a considerable quantity of nodular iron ore. It is this formation, which, rising gradually from the south, forms the surface of those extensive glades or high barren planes, so common along the northern margin of the coal region. These glades are generally covered with a sparse and stunted growth of wood or other vegetation, sustained by a thin and sandy soil, which predominates, except where certain basin-shaped depressions of the surface have received the argillaceous matter derived from the shales. The sandstone may be readily discovered eihter rising in massive beds from beneath the soil, or forming thick ledges along the sides of the ravines and vallies. Though these rocks injure the agricultural character of this district, they are not without their merits, furnishing an admirable building stone, well suited for the construction of furnaces. The best variety of the sandstone for the in-walls of furnaces, is the soft and light gray kind, marked by minute circular blotches, of a brown or black color, imparting a variegated appearance to the rock. This is easily dressed, and resists the fire remarkably well.

Throughout the district in which this rock prevails, we find numerous and valuable deposits of *bog iron ore*. This material is generally precipitated from the waters of Chalybeate springs, which issue along the sides of the ravines, bringing with them the ferruginous particles of the sandstone and the pyritous shales in contact with it.

The extreme margin or outcrop towards the north, has not been accurately traced, except along the Allegheny river. It has been pursued to the north of Teonista creek, where we recognize a well marked stratum, belonging apparently to the bottom of the formation. This is a solid bed of fine grained gray and brownish sandstone, eight feet in thickness. It occurs at the height of fifty feet above the creek, and has the aspect in some places of a true conglomerate, some of its layers imbedding numerous rounded pebbles of white quartz. North of the Teonista, a sandstone, supposed to belong to the same formation, is extensively met with, but the wilderness condition of the country there, has hitherto prevented its being minutely examined.—It is a white sandstone, in some places assuming the features of a conglomerate. On the opposite side, two miles south of the Tytiute creek, a coarse conglomerate is to be seen lying near the summits of the hills. This is traceable to the town of Warren, and is undoubtedly the principal member of F. XII., as it is developed in this part of the country. Ascending French creek, we find this stratum constituting the summits of the hills until we arrive at Meadville. West of the Allegheny river, the rock is extensively developed, being exposed along the Shenango river from Greenville to Sharon and New Castle, affording in many places a superior building stone for the construction of locks, bridges, &c., on the public works. The exact range of this formation will be ascertained during the approaching season. Its average thickness is about one hundred feet.

Rocks below Formation XII.

Beneath the rocks above described, we find on the Allegheny river and its tributaries, a series of well defined strata, consisting of shales and thinly bedded argillaceous sandstones, variously interstratified. The thin arenaceous layers are generally from two to ten inches thick, light blue, fine grained and micaceous, and splitting into neat flags. Other layers contain vegetable impressions, beautiful specimens of which, especially of the *genus fucoides,* abound in this rock. Many of these thin flaggy sandstones exhibit "ripple marks," possessing great breadth and regularity of form. The shales are generally dark colored and soft, and contain thin seams of *iron ore,* identical with that of the coal measures. Thin beds of impure coal have likewise been met with in the upper layers, but no workable stratum is known.

The rocks here mentioned, compose the river hills in the neighborhood of Franklin, where they underlie the thick sandstone above described. They are well exposed along most of the streams of the northern half of Venango county. We have traced them also up the Allegheny river to the mouth of Teonista creek, and up French creek as far as Meadville. On the Shenango and the neighboring streams, they are again met with. The arenaceous limestone described in my last annual report, as a bed two feet in thickness, is a member of this series, and retains its characteristic features over a great range of country, with remarkable constancy,

Our investigations during the past year, not being particularly directed to the country occupied by these lower rocks, it is useless to attempt, at present, a more detailed description. They will be discussed minutely in a subsequent publication,

CHAPTER VI.

Composition of the Iron Ores referred to in this Report.

For the purpose of comparison, and for the sake of convenient reference, I have deemed it best to assemble under one chapter, the various analyses of iron ores referred to in the body of this report, adding some others not specifically alluded to, which belong to formations and localities described in my former annual publications. It will be seen from the list here presented, that this State is remarkable, no less for the singular variety of its iron ores, than for the extraordinary abundance in which some of these prevail. The limited scope of an annual report, and the necessity for more time to comple various branches of research, relating to our ores and the kinds of iron which they are generally best adapted to produce, compel me to defer entering for the present, upon a number of highly useful practical topics suggested by the analytical details here introduced. In the mean while, however, it will interest those who are in any manner connected with the developement of working of our ores, to find the exact composition and relative richness and purity of a large number of them thus displayed.

It will contribute to clearness of arrangement, and at the same time meterially assist us hereafter in arriving at useful general laws, concerning the intimate connections which subsist between the geological situation of these ores and their chemical nature, if we classify their analyses here given, according to the formations in which the ores are found. I shall commence, however, with the specimens derived from the primary rocks, and then present those of the various secondary formations, following the asending order.

Section. I.

Analyses of Iron Ores from the primary rocks of the south-eastern district of the State.

Titaniferous Iron Ore from near Isabella Furnace, on the East Branch of Brandywine creek, Chester county. This ore occurs as a vein in gneiss rock.

DESCRIPTION.

The specimen is of a black color; lustre metallic; cleavage foliated, sometimes granular; has magnetic polarity.

Specific gravity, 4.95

COMPOSITION IN 100 PARTS:

Titanic acid,	22.39
Protoxide of iron,	76.86
Loss,	75
	100.00

This specimen contains 59.44 per cent. metallic iron.

IRON ORE from the Yellow Springs, Chester County.

DESCRIPTION.

The specimen exhibits the usual appearance of brown hematitic iron ore, but has a resinous lustre. It occurs in a ferruginous loam, overlying the gneiss.

COMPOSITION IN 100 PARTS:

Peroxide of iron,	82.91
Alumina,	1.35
Water,	13.90
Silica and insoluble matter,	3.32
	101.48

The proportion of metallic iron in this specimen is 57.55 per cent.

SECTION II.

Analyses of Iron Ores of Formation I.

IRON ORE from Chesnut Hill, near Columbia, Lancaster County.

DESCRIPTION.

Brown; compact; surface mammillary; outer portions of the mass crystalline and radiated. The analysis was performed upon a piece representing the average of the mass.

COMPOSITION IN 100 PARTS:

Peroxide of iron,	84.39
Alumina,	2.46
Silica and insoluble matter,	2.38
Water,	10.99
	100.22

The metallic iron amounts to 58.51 per cent.

Iron Ore from Susan Ann Furnace, York County

DESCRIPTION.

Blackish brown; micaceous, and sandy.

Composition in 100 parts:

Peroxide of iron,	40.71
Peroxide of manganese,	8.91
Alumina, (phosphate),	2.84
Insoluble matter, including phosphoric acid,	39.56
Water,	7.98
	100.00

This specimen contains 28.23 per cent. metallic iron.

Iron Ore from M. G. Ege's Mountain Bank, South of Carlisle Iron Works, Cumberland County.

DESCRIPTION.

Amorphous; color, dull bluish-brown; powder, brown; texture, friable; aspect, earthy.

Composition in 100 parts:

Silica and insoluble matter,	20.10
Alumina,	0.10
Peroxide of iron,	49.80
Peroxide of manganese,	17.55
Water,	12.00
Loss,	0.45
	100.00

This specimen contains 33.86 per cent. metallic iron.

Iron Ore from a Bank half a mile from Carlise Iron Works, M. G. Ege's.

DESCRIPTION.

Dull black color; lustre somewhat metallic; sub-crystalline; slightly magnetic: has some resemblance to the ores of the Warwick and other mines adjacent to trap dykes.

COMPOSITION IN 100 PARTS:

Magnetic oxide of iron,	64.79
Peroxide of iron,	27.93
Oxide of Managanese,	a trace
Alumina,	a trace
Silica and insoluble matter,	3.30
Water,	3.81
	99.83

This ore contains 65.88 per cent. metallic iron.

IRON ORE from the Mountain Ore Bank of Carlisle Iron Works.

DESCRIPTION.

Brown; mottled; somewhat cellular; locally called "honey-comb ore."

COMPOSITION IN 100 PARTS:

Peroxide of iron,	70.04
Peroxide of manganese,	3.32
Alumina,	a trace
Silica and insoluble matter,	16.32
Water,	10 96
	100.64

This specimen contains 48.56 per cent. metallic iron.

IRON ORE from General T. C. Miller's Mountain Bank, Cumberland Furnace, Cumberland county.

DESCRIPTION.

Brown hemetite; botryoidal on the surface, and somewhat porous; color of mass orchrey.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	12.0
Alumina,	0.4
Peroxide of iron,	74.8
Water,	12.0
Loss,	0.8
	100.0

This specimen contains 52·36 per cent. metallic iron.

IRON ORE from Peffer's Bank, six miles south-west of Carlisle, Cumberland county

DESCRIPTION.

Amorphus, compact; color dark brown; interspersed with light colored ocherous matter.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter, ...	12.1
Alumina, ...	4.3
Peroxide of iron, ...	69,4
Water, ...	14.0
Loss, ...	0.2
	100.0

This specimen contains 48.58 per cent. metallic iron.

IRON ORE one mile and three-fourths from Carlisle Iron Works, Cumberland county.

DESCRIPTION.

Pipe ore; pipes small; color dark chesnut brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter, ...	4.05
Alumina, ...	a trace
Peroxide of iron, ...	85.65
Water, ...	8.80
Loss, ...	0.90
	100.00

This specimen contains 59.95 per cent. metallic iron.

IRON ORE from Pond Bank, used at Caladonia Furnace, Stevens and Paxton's, Franklin county.

DESCRIPTION.

Hematitic; imperfectly crystallized; form rounded; color dark chesnut brown. Specimen consists of a fragrant of a hollow spherical ball.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	9.30
Alumina	trace
Peroxide of iron,	79.05
Water	12.00
	100.35

This specimen contains 55.33 per cent. metallic iron.

IRON ORE from the Hill-Bank used at Southampton Furnace, Franklin county, (better portion.)

DESCRIPTION.

Texture cellular; surface of cells sometimes lined with crystalized hematite; color dark chesnut brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	5.90
Alumina,	2.70
Peroxide of iron,	78.85
Maaganese,	trace
Water,	12.50
Loss,	0.05
	100.00

This specimen contains 55.19 per cent metallic iron.

IRON ORE from the Hill Bank, used at Southampton Furnace, Franklin county, (inferior portion.)

DESCRIPTION.

Amorphous, cellular, dark brown alternating with light colored matter.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	5.80
Alumina,	1.80
Peroxide of iron,	76.30
Manganese,	1.00
Water,	14.50
Loss,	0.60
	100.00

This specimen contains 53.41 per cent. metallic iron.

IRON ORE from Montalto Furnace, Hughes' Franklin county, (Lower Ore.)

DESCRIPTION.

Texture cellular; color, dark chesnut brown; walls of cells compact, interior occupied by light colored ochreous matter.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	7.0
Alumina,	3.3
Peroxide iron,	75.2
Water,	14.0
Loss,	0.5
	100.0

This specimen contains 52.64 per cent. metallic iron.

IRON ORE from Montalto Furnace, Franklin county, (Upper Ore.)

DESCRIPTION.

Mottled brown and ochrey; in some parts compact; in others soft and cellular, and distinctly laminated.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	13.3
Alumina,	2.5
Peroxide of iron,	71.0
Water,	12.6
Loss,	0.6
	100.0

This specimen contains 49.70 per cent. metallic iron.

IRON ORE from a Bank one mile southwest from Hughes' Forge, Franklin county.

DESCRIPTION.

Texture, compact; massive; color, dark brown; aspect of fresh surface somewhat resinous.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	2.80
Alumina,	1.40
Peroxide of iron,	79.10
Sesqui oxide of manganese,	4.00
Water,	12.00
Loss,	0.70
	100.00

This specimen contains 55.37 per cent. metallic iron.

Iron Ore use at Pond Furnace, (Moore's,) Franklin County.

DESCRIPTION.

Impure hydrated oxide; texture, hœmatitic; semi-crystalline on surface, which is covered with mammillary protuberances; color of mass, brownish yellow—of surface, dark brown.

Composition in 100 parts:

Silica and insoluble matter,	10.0
Alumina,	2.6
Peroxide of iron,	73.5
Manganese,	a trace
Water,	13.0
	99.1

This specimen contains 51.35 per cent. metallic iron.

Section III.

Analyses of the Iron Ores of the Limestone Formation II.

Iron Ore from Miller's Mine, four miles North-West of Allentown, West side of the Lehigh River, Lehigh County.

DESCRIPTION.

Brown; stalactitic; variety, "pipe ore;" the cavities partly filled with pulverulent yellow oxide of iron.

Composition in 100 parts:

Peroxide of iron,	86.59
Alumina,	a trace
Silica and insoluble matter,	3.08
Water,	11.31
	100.98

This specimen contains 60.04 per cent. metallic iron.

Iron Ore from Balliat's Mine, five miles North-West of Allentown, Lehigh County.

DESCRIPTION.

Color, liver brown; compact; superficial portion crystalline, radiated, and mammillary. The latter part was selected for analysis.

Composition in 100 parts:

Peroxide of iron,	83.22
Alumina,	0.21
Silica and insoluble matter,	4.81
Water,	12.40
	100.64

This specimen contains 57.61 per cent. metallic iron.

Iron Ore from Balliat's Mine, five miles North-West of Allentown, Lehigh County.

DESCRIPTION.

Color, reddish brown; structure, lamellar; compact.

Composition in 100 parts:

Peroxide of iron,	84.00
Alumina,	1.00
Silica and insoluble matter,	6.50
Water,	9,50
	101.00

This specimen contains 58.24 per cent. metallic iron.

Iron Ore from Daniel Shwartz's Mine, half a-mile South-West of Emmaus, Lehigh County.

DESCRIPTION.

Dark brown; compact; lustre somewhat metallic.

Composition in 100 parts:

Peroxide of iron,	79.64
Alumina,	a trace
Silica and insoluble matter,	9.05
Water,	11.40
	100 09

This specimen contains 55.22 per cent. metallic iron.

Iron Ore from a Bank, one mile West of Trexlerstown, Lehigh County.

DESCRIPTION.

Brown; compact; stalactitic; of the structure usually termed "pipe ore."

COMPOSITION IN 100 PARTS:

Peroxide of iron,	87.12
Alumina,	0.40
Silica and insoluble matter,	2.30
Sulphur,	a trace
Water,	10.90
	100.72

This specimen countains 61.03 per cent. metallic iron.

IRON ORE from the Moselem Mine, near Eskhard's Mill, four miles South-West of Kutztown, Berks County.

DESCRIPTION.

Dark, dull brown; compact.

COMPOSITION IN 100 PARTS:

Peroxide of iron,	77.20
Alumina,	2.60
Silica and insoluble matter,	8.90
Water,	11.00
	99.70

This specimen affords 53.53 per cent. metallic iron.

IRON ORE from Gorgas's Bank, three and a-half miles South-West from Harrisburg,—Cumberland County.

DESCRIPTION.

Structure, hematitic; geodiferous; internal surface of goedes covered with a light brown incrustation; color of mass, dark brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	4.80
Alumina,	2.72
Peroxide of iron,	77.20
Manganese,	a trace
Water,	15.15
Loss,	0.13
	100.00

This specimen contains 54.04 per cent. metallic iron.

Iron Ore from Kerr's Fields, eight miles west from Carlisle.

DESCRIPTION.

Structure tending to laminated; color, dark chesnut brown; compact.

Composition in 100 parts:

Silica and insoluble matter,	13.0
Alumina,	4.8
Peroxide of iron,	69.0
Water,	13.0
Loss,	0.2
	100.0

This specimen contains 48.03 per cent. metallic iron.

Iron Ore used at Cumberland Furnace, Gen. T. C. Miller's, occurs one and a half miles from Furnace, in Limestone—Cumberland county.

DESCRIPTION.

Structure, slender pipes; color, chesnut brown; compact.

Composition in 100 parts:

Silica and insoluble matter,	3,89
Alumina,	2.50
Peroxide of iron,	84.60
Lime,	a trace
Water,	8,70
Loss,	0.31
	100.00

This specimen contains 59.22 per cent. metallic iron.

Iron Ore from the Helm Bank, used in Mary Ann Furnace; Whitehill and Ellis's, Cumberland county.

DESCRIPTION.

Structure, somewhat cellular; surface covered with small mammillary protuberances.

Composition in 100 parts :

Silica and insoluble matter,	5.8
Alumina,	2.0
Peroxide iron,	77.2
Water,	14.5
Loss,	0.5
	100.00

This specimen contains 54.04 per cent. metallic iron.

Iron Ore from the Clippinger Bank, used at the Mary Ann Furnace, Cumberland county.

DESCRIPTION.

Structure, large columnar ; pipes, stalactitic ; compact in centre ; on surface, cellular ; color, bright chesnut brown.

Composition in 100 parts :

Silica and insoluble matter,	2.60
Alumina,	50
Peroxide iron,	87.09
Water,	8.81
Loss,	1.00
	100.00

This specimen contains 60.96 per cent. metallic iron.

Iron Ore from the Clippinger Bank, used at the Mary Ann Furnace, Cumberland county.

DESCRIPTION.

Structure, numerous pipes closely cemented together ; color, rich chesnut brown, with a slightly blue tinge.

Composition in 100 parts :

Silica and insoluble matter,	4.9
Alumina,	6
Peroxide iron,	84.6
Manganese,	a trace.
Water,	8.95
Loss,	0.95
	100.00

This specimen contains 59.02 per cent. of metallic iron.

IRON ORE from the Kressler Bank, used in Southampton Furnace, Franklin county.

DESCRIPTION.

Amorphous, cellular, somewhat laminated; color brown mottled.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	9.0
Alumina,	2.9
Peroxide of iron,	75.0
Manganese,	a trace
Water,	13.0
Loss,	0.1
	100.0

This specimen contains 52.5 per cent. metallic iron.

IRON ORE from the Rail road Bank used at the Southampton Furnace, Franklin County.

DESCRIPTION.

Structure cellular; color brown: compact.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	14.7
Alumina,	0.8
Peroxide of iron,	72.0
Manganese,	a trace
Water,	12.0
Loss,	0.5
	100.0

This specimen contains 50.4 per cent. metallic iron.

IRON ORE from the old diggings at Pilgrim Bank, north-east from Shippensburg.

DESCRIPTION.

Structure closely adhering pipes so as to be almost obliterated; color dark chesnut brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	6.8
Alumina,	4.0
Peroxide of iron,	77.7
Water,	11.0
Loss,	5
	100.0

This specimen contains 54.39 per cent. metallic iron.

IRON ORE from the Roxbury Bank, west of Shippensburg, Franklin County.

DESCRIPTION.

Pipe ore, the pipes adhering closely, composed of an intermixture of a compact chesnut brown oxide, with a light colored ochreous substance.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	9.3
Alumina,	3.6
Peroxide of iron,	75.1
Water,	12.0
	100.0

This specimen contains 52.57 per cent. metallic iron.

IRON ORE from the Green Village Bank, Stevens and Paxton's, Franklin county.

DESCRIPION.

Structure, long slender pipes of uniform texture throughout; color brownish yellow.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	4.2
Alumina,	0.9
Peroxide of iron,	82.6
Water,	12.0
Loss,	0.3
	100.0

This specimen contains 57.82 per cent. metallic iron.

IRON ORE from Heifner's Bank, used in Caledonia Furnace, Stevens and Paxton's, Franklin county.

DESCRIPTION.

Hydrated oxide; color, bright chesnut brown; compact.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	10.8
Alumina,	a trace.
Peroxide iron,	76.6
Manganese,	a trace.
Water,	12.5
Loss,	0.1
	100.0

This specimen contains 53.62 per cent. metallic iron.

IRON ORE from near Heilner's, six miles from Caledonia Furnace, Franklin county.

DESCRIPTION.

Structure; pipes closely adhering; color, distinct brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	6.7
Alumina,	a trace.
Peroxide of iron,	81.6
Water,	11.4
Loss,	0.3
	100.0

This specimen contains 57.12 per cent. metallic iron.

IRON ORE from Middauer's, three miles north-east of Waynesburg, Franklin county.

DESCRIPTION.

Massive compact; fracture, slightly conchoidal; lustre, somewhat resinous; color, brownish red, with a slight bluish tinge.

Composition in 100 parts:

Silica and insoluble matter,	14.0
Alumina,	0.5
Peroxide iron,	72.6
Manganese,	a trace.
Water,	12.5
Loss,	0.4
	100.0

This specimen contains 50.82 per cent. metallic iron.

Iron Ore from M'Dowell's Bank, five miles north-east from Mercersburg, Franklin county, (called garlic ore.)

DESCRIPTION.

Amorphous; cellular; color, bright brown.

Composition in 100 parts:

Silica and insoluble matter,	4.80
Alumina,	1.50
Peroxide of iron,	83.60
Manganese,	a trace.
Arsenic,	a trace.
Water,	9.40
Loss,	0.70
	100.00

This specimen contains 58.82 per cent. of metallic iron, and possesses a trace of arsenic.

Iron Ore from Carrick Furnace, Path Valley, Franklin county.

DESCRIPTION.

Structure, nodular; surface, mammillary; with interspersed argillaceous specks.

Composition in 100 parts:

Silica and insoluble matter,	17.40
Alumina,	5.80
Peroxide of iron,	59.50
Peroxide of manganese,	8.30
Water,	8.80
Loss,	0-20
	100.00

This specimen contains 41.65 per cent. metallic iron.

Iron Ore from Carrick Furnace, Path Valley, Franklin county.

DESCRIPTION.

Structure, cellular; interior of the cells coated with a buff colored ochreous deposit; color, dark chesnut brown; called "honey-comb ore."

Composition in 100 parts:

Silica and insoluble matter,	3.80
Alumina,	2.25
Peroxide of iron,	84.30
Water,	8.85
Loss,	0.80
	100.00

This specimen contains 59.01 per cent. metallic iron.

Iron Ore from the Bull Bank of Pennsylvania Furnace, Centre county.

DESCRIPTION.

Hematitic; somewhat mottled; compact; fracture, conchoidal; color, chocolate brown.

Composition in 100 parts:

Silica and insoluble matter,	2.30
Alumina,	a trace
Peroxide of iron,	86.40
Manganese,	a trace
Water,	11.00
Loss,	0.30
	100.00

This specimen contains 60.48 per cent. metallic iron.

Iron Ore from Old Pennsylvania Furnace Bank, Centre county.

DESCRIPTION.

Pipe ore; the pipes small and closely set; color a dark chesnut brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	5.3
Alumina,	a trace
Peroxide of iron,	82.2
Oxide of manganese,	a trace
Water,	12.0
Loss,	0.5
	100.00

This specimen contains 57.54 per cent. metallic iron.

IRON ORE from the Pennington Bank, two and a-half miles South-West of Warrior Mark town, Huntingdon county.

DESCRIPTION.

Hematitic; cellular and slightly columnar; color, rich chesnut brown; surface of fresh fracture of a velvet-like lustre.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	8.8
Alumina,	0,5
Peroxide of iron,	75.2
Manganese,	a trace
Lime,	a trace
Water,	15.0
Loss,	0.5
	100.0

This specimen contains 52.64 per cent. metallic iron.

IRON ORE from Springfield Furnace Ore Bank, Morrison Cove, Huntingdon county.

DESCRIPTION.

Structure, cellular; interior of cells coated with blue-black incrustation; color, dark chesnut brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	4.8
Alumina,	0.3
Peroxide of iron,	79.6
Sesqui-oxide of manganese,	3.0
Lime,	a trace
Water,	12.0
Loss,	0.3
	100.0

This specimen contains 55.72 per cent. metallic iron.

IRON ORE from Bomb-Shell Bank, of Rebecca Furnace, Morrison Cove, Huntingdon county.

DESCRIPTION.

A section of hollow geode or bomb, hematitic fibours crystaline, inner surface botryoidal, and iridescent.

COMPOSITION IN 100 PARTS:

Peroxide of iron,	84.22
Oxide of manganese,	0.41
Alumina,	0.65
Silica and insoluble matter,	6.43
Water,	8.25
	99.95

The proportion of metallic iron in this ore is 58.95 per cent.

IRON ORE from the Red Bank, three miles south-west of Rebecca Furnace, Morrison's Cove, Huntingdon county.

DESCRIPTION.

Texture, compact and close grained, somewhat jaspery; fracture slightly conchoidal; color bright reddish brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	32.1
Alumina,	a trace
Peroxide of iron,	57.2
Lime,	a trace
Water,	9.8
Loss,	0.9
	100.0

This specimen contains 40.04 per cent. metallic iron.

IRON ORE from Sarah Furnace Ore Bank, four miles south of M'Kee's Gap, Morrison's Cove, Bedford county.

DESCRIPTION.

Blackish brown; cellular; with concentric layers of denser crylstaline fibrous hematite.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	11.7
Alumina,	a trace.
Peroxide of iron,	76.5
Manganese,	a trace.
Water,	11.6
Loss,	0.2
	100.0

This specimen contains 53.55 per cent. metallic iron.

SECTION VI.

Analyses of Iron Ores of Formation III. (Slate.)

IRON ORE from the south side of Lowrey's Knob; Hanover Ore Bank, two and a-half miles north-east of Hanover Furnace, Bedford county.

DESCRIPTION.

Compact; brittle semi-crystalline; color, dark chocolate brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	2.80
Alumina,	3.20
Peroxide of iron,	80.20
Manganese,	a trace
Water,	12.90
Loss,	0.90
	100.00

This specimen contains 56.14 per cent. metallic iron.

IRON ORE from the Hanover Ore Bank.—Kind chiefly used at the Furnace.

DESCRIPTION.

Compact; fracture conchoidal; color dull brown; surface in patches, coated with a greenish black shining incrustation.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	11.5
Alumina,	2.0
Peroxide of iron,	73.6
Manganese,	a trace.
Water,	11.5
Lime,	a trace.
	98.6

This specimen contains 51.52 per cent. metallic iron.

IRON ORE from M'Naughton's, one and a-half miles west from Mercersburg, Franklin county.

DESCRIPTION.

A bog ore; dull brown, and cellular. It overlies the slate F. III.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	9.20
Alumina,	0.73
Peroxide of iron,	69.60
Water,	20.00
Loss,	0.47
	100.00

This specimen contains 48.72 per cent. metallic iron.

SECTION V.

Analyses of Iron Ores of Formation V.

IRON ORE from the Sandstone ridge, north-west side of Little Cove, four and a-half miles north of Warren Iron Works, Franklin county. (Specimen taken near the surface.)

DESCRIPTION.

Structure, slightly porous; laminated; fossiliferous; color, reddish brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	5.3
Alumina,	6.0
Peroxide of iron,	83.0
Manganese,	a trace
Lime,	0.5
Water,	5.1
Loss,	0.1
	100.00

This specimen contains 58.1 per cent. metallic iron.

Locality.—North-west side of Dickey's mountain, half a mile south of Lower Hanover Forge, Bedford county.

DESCRIPTION.

Structure, laminated; texture, earthy; color, dark chesnut brown, in some parts, almost black.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	39.3
Alumina,	a trace
Peroxide iron,	52.0
Maaganese,	a trace
Water,	9.0
	100.3

This specimen contains 36.4 per cent. metallic iron.

IRON ORE from Matilda Furnace, two miles north-west of Newton Hamilton, Huntingdon county. (Upper division of the fossiliferous ore.)

DESCRIPTION.

Reddish brown, speckled with scales of grey micaceous oxide; cellular, from the removal of numerous minute fragments of fossils; breaks into rectangular pieces; streak red.

Specific gravity,	3.50

COMPOSITION IN 100 PARTS:

Peroxide of iron,	74,76
Alumina,	5.06
Lime,	1.35
Manganese,	a trace
Silica and insoluble matter,	13.04
Undetermined matter,	2.11
Water,	3.82
	100.14

This specimen contains 51.84 per cent metallic iron.

Iron Ore from Matilda Furnace.—(Lower division of the same bed.)

DESCRIPTION.

Brown, with a rectangular fracture; consists of coarse grains of siliceous sand, cemented by brown oxide of iron.

Composition in 100 Parts:

Peroxide of iron.	44.07
Manganese,	a trace
Alumina	1.39
Lime,	0.49
Silica and insoluble matter,	52.33
Water	2.62
	100.90

This specimen contains only 30.56 per cent. metallic iron. It is so highly siliceous as to make the smelting of it unprofitable.

Iron Ore used at Hopewell Furnace, from a vein on Dr. Andrew M'Dowell's land, found on the bank of Yellow creek, in Lick Hill, Woodcock Valley, Bedford county.

DESCRIPTION.

Structure, highly fossiliferous; particles of carbonate of lime disseminated through the mass; color, a pale red.

Composition in 100 parts:

Peroxide of iron, Carbonate of the protoxide,	46.50
Alumina,	4.80
Carbonate of lime,	31.01
Silica and insoluble matter,	16.30
Water,	1 00
	99.61

From 39.60 per cent. of peroxide of iron obtained in the analysis, the amount of metallic iron in this specimen, is, by calculation, 27.72.

Iron Ore used at Hopewell Furnace, *softest kind,* obtained from upper vein two miles from the Furnace, Bedford county.

DESCRIPTION.

Texture, brittle and crumbly; disposed to break into irregular rhomboidal masses; color in mass, brown—of powder, rich purple brown; micaceous oxide sparsely disseminated throughout the mass; fossiliferous.

Composition in 100 parts:

Silica and insoluble matter,	13.85
Alumina,	4.50
Peroxide of iron,	78.05
Sesquioxide of manganese,	0.68
Lime,	a trace
Water,	3.00
	100.28

This specimen contains 54.95 per cent. metallic iron.

Iron Ore used at Hopewell Furnace *compact kind*, obtained from upper vein, two miles from the Furnace.

DESCRIPTION.

Texture, compact; color of mass, reddish grey—of powder, light brown; structure, micaceous; fossiliferous.

Composition in 100 parts:

Silica and insoluble matter,	8.8
Alumina,	1.0
Peroxide of iron,	55.2
Peroxide of manganese,	0.5
Lime,	17.6
Carbonic acid,	13.8
Water,	2.5
Loss,	0.6
	100.0

This specimen contains 38.64 per cent. metallic iron.

Iron Ore from the principal opening in the hill between Barre Forge and the Little Juniata, Huntingdon county—(lower portion of the vein.)

DESCRIPTION.

Structure, crystalline; distinctly fossiliferous; color, reddish grey calcareous.

Composition in 100 parts:

Silica,	3.00
Alumina,	0.50
Peroxide of iron,	43.55
Proto-carbonate of iron,	3.56
Sesquioxide of manganese,	0.50
Carbonate of lime,	46.76
Water,	1.50
	99.37

This specimen contains 32.2 per cent. metallic iron.

Iron Ore from near Little Juniata, at Barre Forge, North-East of the Forge—(average specimen of the vein.)

DESCRIPTION.

Compact; breaks into rectangular plates; color, reddish grey; micaceous.

Composition in 100 parts:

Silica and insoluble matter,	7.50
Alumina,	1.40
Protoxide of iron,	57.00
Peroxide of manganese,	0.60
Lime,	18.00
Carbonic acid,	14.10
Water,	2.00
	100.60

This specimen contains 39.9 per cent. metallic iron.

Section VI.

Analyses of Iron Ores of Formation VI.

Iron Ore from Allegheny Furnace Ore Bank, six miles from Tuckahoe, Huntingdon county. This ore comes from near the contact of F. VI. and F. VII.

DESCRIPTION.

Amorphus; compact; brittle; fracture earthy; color, dark bluish brown.

Composition in 100 parts:

Silica and insoluble matter,	6.0
Alumina,	a trace
Peroxide of iron,	82.2
Peroxide of manganese,	8.0
Water,	4.0
	100.2

This specimen contains 57.54 per cent. metallic iron.

Iron Ore from Allegheny Furnace, six miles from Tuckahoe, Huntingdon county.

DESCRIPTION.

Pipe ore; the stems or pipes large; portions of the surface irridescent.

Composition in 100 parts:

Peroxide of iron,	86.91
Alumina,	0.22
Silica and insoluble matter,	1.93
Water,	10.44
	99.50

This specimen contains 60.26 per cent. metallic iron.

Iron Ore from one mile South-West of Bell's Furnace, Tuckahoe, Huntingdon county. This ore seems to be derived from F. VII.

DESCRIPTION.

Color, a dark chocolate brown; lustre somewhat resinous. This variety is said to make a brittle iron.

Composition in 100 parts:

Peroxide of iron,	73.28
Oxide of Manganese,	a trace
Alumina,	5.52
Silica and insoluble matter,	12.88
Water,	9.38
	101.06

This specimen contains 50.81 per cent. metallic iron.

SECTION VII.

Analyses of Iron Ores from Formation VIII.

IRON ORE from the Synclinal Axis, Nevey's Bank, one and a half miles South-east of Newton Hamilton, Lewistown Valley, Huntingdon county. This ore occurs near the contact of Fs. VII. and VIII.

DESCRIPTION.

Structure imperfectly laminated; somewhat cellular; color, dull mottled brown; highly silicious.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	20.5
Alumina,	4.6
Peroxide of iron,	65.4
Manganese,	a trace
Water,	9.0
Loss,	0.5
	100.0

This specimen contains 45.78 per cent. metallic iron.

IRON ORE from the Synclinal Axis, half a mile West of Brookland Furnace, (Walter's Bank,) Lewistown Valley, Mifflin county. Occurs near the contact of Fs. VII. and VIII.

DESCRIPTION.

Structure, hematitic; color, rich chocolate brown; surface velvet like, and occasionally brilliantly irridescent.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	18.80
Alumina,	5.80
Peroxide of iron,	66.00
Water,	9.00
Manganese,	a trace
	99.60

This specimen contains 46.2 per cent. metallic iron.

UofM

Iron Ore from Warren Ore Bank, North-West side of Synclinal Axis of Little Cove, and a half a mile North-West of the Iron Work, Franklin county.

DESCRIPTION.

Structure, hollow or shell-like; color, dark brown.

Composition in 100 parts:

Silica and insoluble matter,	18.8
Alumina,	a trace
Peroxide of iron,	67.6
Manganese,	a trace
Water,	12.7
Loss,	0.9
	100.0

This specimen contains 47.32 per cent. metallic iron.

Iron Ore from Brown's Furnace, Little Cove, Franklin county.

DESCRIPTION.

Compact; nodular; color, bluish grey. Occurs as a regular stratum in the lower beds of F. VIII. in various places.

Composition in 100 parts:

Silica and insoluble matter,	17.00
Alumina,	1.50
Protoxide of iron,	50.00
Carbonic acid,	30.55
Water,	1.00
	100.05

This specimen contains 38.8 per cent metallic iron. This valuable ore has never been worked, though it is obviously rich enough and sufficiently pure. The quantity of it in many of the synclinal basins of F. VIII., where it often forms a regular seam, is inexhaustible.

SECTION VIII.

Analysis of Iron Ores from Formations IX.

IRON ORE from Larry's Creek, Lycoming county, (near the contact of F. VIII, and F. IX.

DESCRIPTION.

Purplish brown; streak red; structure stratified or laminated; consists of flattish granules; fossiliferous; somewhat sandy.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	32.30
Alumina,	3.00
Peroxide of iron,	61.20
Carbonate of lime,	1.30
Water,	2,20
	100.00

This specimen contains 42.84 per cent. metallic iron. It does not manifest, by analysis, the faintest trace of manganese.

IRON ORE from the north-west side of Big Scrub Bridge, and two and a half miles south-west of the turnpike. Occurs near the contact of F. IX. F. X.

DESCRIPTION.

Compact, fibrous, hematitic; color, dark mahogany brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	2.85
Alumina,	a trace
Peroxide of iron,	84.54
Water,	12.00
	99.39

This specimen contains 59.17 per cent. metallic iron.

UofM

SECTION IX.

Analysis of Iron Ores from formation XI.

IRON ORE from Hopewell Furnace, from old bank, on north side of the river. The best kind used from this opening, occurs near the contact of F. X. and F. XI.

DESCRIPTION.

Nodular, geodiferous; surface coated with a pinkish deposite—interiorly by a velvet like oxide.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	32.1
Alumina,	2.5
Peroxide of iron,	60.0
Lime,	0.4
Manganese,	a trace
Water,	4.5
Loss,	0.4
	100.0

This specimen contains 42.0 per cent. metallic iron.

IRON ORE from a vein in a tunnel in Terrace mountain, Hopewell Furnace. Occurs near the contact of F. X. and F. XI.

DESCRIPTION.

Massive, compact; fracture, coincidal; lustre, dull; color, chocolate brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	2.30
Alumina,	a trace.
Manganese,	a trace
Peroxide of iron,	84.00
Water,	13.50
Loss,	0.20
	100.00

This specimen contains 58.8 per cent. metallic iron.

Iron Ore from Ralston, Lycoming county, (upper part of the bed.)

DESCRIPTION.

Spathose; texture, somewhat laminated; siliceous; color, ash grey.

Composition in 100 parts:

Silica and insoluble matter,	28.80
Alumina,	1.00
Protoxide of iron,	41.22
Lime,	0.50
Carbonic acid,	24.00
Water,	4.28
Loss,	0.5
	100.00

This specimen contains 32.06 per cent. metallic iron.

Iron Ore from the upper part of a bed in West Hill, Johnson's creek Blossburg.

DESCRIPTION.

Spathose; texture somewhat laminated; color, light grey, with faint pink hue; highly siliceous.

Composition in 100 parts:

Silica and insoluble matter,	66.80
Alumina,	0.50
Protoxide of iron,	18.54
Carbonic acid,	11.30
Manganese,	a trace.
Water,	2.56
Loss,	0.30
	100.00

This specimen contains only 14.42 per cent. metallic iron.

Iron Ore from the bed at Astonville, Frozen run, Lycoming county.

DESCRIPTION.

Light grey, mottled; consists of minutely chrystaline carbonate of iron; of a pinkish yellow color, sometimes velvet like.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	28.7
Alumina,	0.8
Protoxide of iron,	42.2
Carbonate of lime,	0.6
Carbonic acid	25.8
Water,	1.5
	99 6

This specimen contains 32.8 per cent. metallic iron.

IRON ORE from the lower band of Red Shale, F. XI., Farrandsville, Lycoming county.

DESCRIPTION.

Color, purplish red; compact dense, nodular, and very slightly crystalline.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	25.6
Alumina,	3·6
Peroxide of iron,	68.4
Carbonic acid and water,	2.0
Lime,	a trace
	99.6

This specimen contains 47.88 per cent. metallic iron.

SECTION X.

Analyses of Iron Ores from the Coal Measures of F. XIII., (Anthracite Coal Region.)

IRON ORE from Pottsville, from a bed of huge balls, in a tunnel running north from the Gate vein.

DESCRIPTION.

Texture compact, and close grained; fracture, slightly conchoidal; color, slate blue; feel, slightly unctuous; breaks into iregular shaped masses, which are covered at the surface, of a contact with thin plates of white silicious matter.

COMPOSITION IN 100 PARTS:

Carbonate of iron,	80.85
Carbonate of lime,	1.00
Carbonate of Magnesia	3.86
Alumina,	2.06
Silica and insoluble matter,	9.08
Carbonaceous matter,	1.02
Water,	2.00
	99.87

This specimen contains 39.09 per cent. metallic iron.

IRON ORE from the tunnel of the North American Works, Pottsville.

DESCRIPTION.

Compact; texture, rather coarse grained; feel, unctious; interspersed with irredescent spots of iron Pyrites.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	50.80
Alumina,	2.80
Carbonate of iron,	39.82
Carbonate of lime,	1.00
Carbonate of Magnesia,	2.35
Manganese,	a trace
Sulphur,	a trace
Water,	2.00
Carbonaceous matter,	1.20
	99.97

This specimen contains 19.21 per cent. metallic iron.

IRON ORE from the outcrop of a bed next below the rabbit hole vein, Eyre tract, Pottsville.

DESCRIPTION.

Occurs in oval lenticular shaped masses; external structure, concentric; color, dull brown; internally, slate blue.

COMPOSITION IN 100 PARTS:

Carbonate of iron,	65.30
Oxide of manganese,	a trace
Alumina,	3.20
Carbonate of lime,	1.50
Carbonate of Magnesia,	1.60
Silica and insoluble matter,	25.00
Organic matter,	1.22
Water,	1.50
	99.32

This specimen contains 32.6 per cent. metallic iron.

IRON ORE from the outcrop of a bed found ten feet below a seam of coal, opened by B. Patterson, Pottsville.

DESCRIPTION.

Irregularly rounded mass, very hard; color, light slate blue; highly siliceous.

COMPOSITION IN 100 PARTS:

Carbonate of iron, ...	67.80
Carbonate of manganese, ...	1.00
Carbonate of lime, ...	0.39
Carbonate of magnesia, ...	a trace.
Alumina, ...	1.30
Silica and insoluble matter, ...	29.00
Water, ...	0.50
	99.99

This specimen contains 33.9 per cent. metallic iron.

IRON ORE from M'Carty's Tunnel, Pottsville.

DESCRIPTION.

Iregular rounded mass, somewhat micaceous; feel, slightly unctuous; colr slate blue, and in the centre a little irridescent.

COMPOSITION IN 100 PARTS:

Peroxide of iron, ...	19.36
Carbonate of iron	26.02
Manganese, ...	a trace
Alumina, ...	2.08
Carbonate of lime, ...	0.07
Carbonate of Magnesia	4.04
Silica and insoluble matter, ...	46.40
Water, ...	1.00
	98.97

This specimen contains 26.39 per cent. metallic iron.

IRON ORE from one of several bands near the end of Mann and Williams' Tunnel, Pottsville.

DESCRIPTION.

Texture, compact and close grained; aspect, earthy; fracture, slaty; surface, smooth; feel, unctuous; color, slate blue.

Composition in 100 parts:

Carbonate of iron,	72.00
Manganese,	a trace
Carbonate of lime,	2.08
Carbonate of magnesia,	1.52
Alumina,	1.60
Silica and insoluble matter,	21.50
Carbonaceous matter,	1.00
Sulphur,	a trace
Water,	3,0
	100.00

This specimen contains 36 per cent. metallic iron.

Iron Ore from a bed south of the false Salem vein, Guinea Hill, on Market street, Pottsville.

DESCRIPTION.

Irregular nodular mass, compact interiorly ; on surface, brittle and somewhat laminated; color interior, slate blue; surface, ocherous brown; aspect, earthy and micaceous.

Composition in 100 parts:

Peroxide and carbonate of iron,	56.20
Alumina,	2.80
Manganese,	a trace
Carbonate of lime,	a trace
Carbonate of magnesia,	0.8
Silica and insoluble matter,	39.30
Carbonaceous matter,	0.50
Water,	0.20
	99.80

The proportion of metallic iron in this specimen is 32.48 per cent.

Iron Ore from a bed behind a barn on Guinea Hill, Pottsville.

DESCRIPTION.

Similar to the above, except that the external portion is more distinctly laminated.

COMPOSITION IN 100 PARTS:

Peroxide and carbanate of iron,	63.3
Alumina,	2.8
Lime,	a trace
Carbonate of magnesia,	1.4
Silica and insoluble matter,	32.0
Water,	0.4
	99.9

This specimen contains 30.66 per cent. metallic iron.

IRON ORE from Pottsville, from a collection of veins near the north end of Mann and Williams' tunnel.

DESCRIPTION.

Texture, compact and close grained; aspect, earthy; fracture, slightly conchoidal; feel, little unctuous; color, slate blue.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	15.00
Alumina,	2.60
Peroxide and carbonate of iron,	79.20
Lime,	a trace.
Magnesia,	a trace.
Manganese,	a trace.
Water,	1.60
Carbonaceous matter,	1.30
	99.70

This specimen contains 2.84 per cent. metallic iron.

IRON ORE from a bed behind a barn on Guinea hill, north of the false Salem; vein, fourteen inches thick.—Pottsville.

DESCRIPTION.

Texture, compact; close grained; fracture, slightly conchoidal; aspect, earthy; color, slate blue; feel, smooth and unctuous.

COMPOSITION IN 100 PARTS;

Silica and insoluble matter,	21.00
Alumina,	1.60
Peroxide of iron,	44.64
Insoluble carbonaceous matter,	1.00
Lime,	0.70
Magnesia,	0.70
Carbonic acid,	27.05
Water,	1.40
	99.54

This specimen contains 34.72 per cent. metallic iron.

Iron Ores of the Bituminous Coal Measures

IRON ORE from the "Deal Bank," one mile south of Shippenville, Clarion county. (Buhr-stone ore.)

DESCRIPTION.

Hematitic; cellular; interior cells coated with small crystalline oxide; color, purple brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	2.81
Alumina,	a trace.
Peroxide of iron,	83.00
Sesquioxide of manganese,	2 00
Water,	12.50
	100.31

The proportion of metallic iron in this specimen, is 58.1 per cent.

IRON ORE from the land of Mr. M'Ginnis, used at Porterfield's Furnace, Clarion county. (Buhr-stone ore.)

DESCRIPTION.

Hematic, slightly cellular; color, purplish brown.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter,	5.30
Alumina,	a trace.
Peroxide of iron,	79.20
Sesquioxide of manganese,	1.00
Water,	14.00
	99.50

This specimen contains 55.44 per cent. metallic iron.

IRON ORE from the land of Mr. M'Ginnis, used at Porterfield's Furnace, Clarion county. (Buhr-stone ore.)

DESCRIPTION.

Irregular shaped: nodular, with a dense nucleus enveloped by a laminated and concentrive crust; color, reddish brown; structure, somewhat oolitic.

Composition in 100 parts:

Silica,	21.50
Alumina,	0.70
Peroxide of iron,	45.04
Carbonic acid,	25.30
Carbonate of lime,	1.78
Carbonate of manganese,	1.00
Water,	4.00
	99.68

This specimen contains 35.03 per cent. metallic iron.

Iron Ore from Rockland Furnace, Venango county, (Nodular, or Ball ore.)

DESCRIPTION.

Texture, hard and compact; nodular; fracture, somewhat conchoidal; color, dark slate blue—externally brown.

Composition in 100 parts:

Carbonate of iron,	79.90
Carbonate of lime,	2.60
Oxide mangacese,	.05
Alumina,	.50
Silica and insoluble matter,	14.80
Organic matter,	a trace
Water,	2.00
	99.85

This specimen countains 38.05 per cent. metallic iron.

Iron Ore from the land of Joseph Kutcher, Clarion county, (Buhrstone ore.)

DESCRIPTION.

Spathose; texture, compact; fracture, conchoidal; color, bluish grey.

Composition in 190 parts:

Carbonate of iron,	76.30
Alumina,	1.00
Carbonate of lime,	6.00
Silica and insolubie matter,	13.30
Oxide of manganese,	.50
Water,	2.00
	99.10

The proportion of metallic iron in this specimen, is 59.03 per cent.

Iron Ore from the land of Jos. Kucher, Clarion co. (Buhr stone ore.)

DESCRIPTION.

Texture, soft and porous; fracture, irregular; aspect, earthy; color, dull red, speckled with white spots.

COMPOSITION IN 100 PARTS :

Peroxide of iron, and	87.04
Carbonate of iron, ...	
Alumina, ...	.05
Carbonate of lime, ...	4.06
Silica and insoluble matter, ...	5.08
Water, ...	1.05
	99.08

This specimen contains 54.14 per cent metallic iron.

IRON ORE from Lucinda Furnace, (Huges's) Clarion county, (Buhr-stone ore.)

DESCRIPTION.

Structure, geodiferous, cellular; walls composed of imperfectly crystallized hæmatite; interior of cells coated with a firm ocherous deposite; color, chesnut brown.

COMPOSITION IN 100 PARTS ;

Silica and insoluble matter, ...	4.80
Alumina, ...	0.54
Peroxide of iron, ...	78.22
Sesquioxide of manganese, ...	1.50
Water, ...	14.20
	99.29

This specimen contains 54.75 per cent. of metallic iron.

IRON ORE from Phipp's furnace, Scrub Grass township, Venango co. (ball ore.)

DESCRIPTION.

Texture, hard, compact; fracture conchoidal; somewhat nodular; interior, slate blue—outside brown.

COMPOSITION IN 100 PARTS ;

Peroxide of iron and carbonate of iron, ..	96.00
Manganese, ...	a trace.
Alumina, ...	0.50
Lime, ...	a trace.
Silica and insoluble matter, ...	2.10
Organic matter, ...	a trace.
Water, ...	1.00
	99.60

This speimen contains 41.3 per cent. metallic iron.

O

Iron Ore from Hickory Furnace, Butler county, (Buhr-stone ore.)

DESCRIPTION.

Nodular, cellular; walls of cells composed of chrystalized hematite and lined with a rich velvet like oxide; color, bright chesnut brown; surface coated with a thin argillaceous crust.

Composition in 100 parts:

Silica and insoluble matter,	20.0
Alumina,	1.8
Peroxide of iron,	65.2
Peroxide of manganese,	1.5
Water,	11.0
	99.5

The amount of metallic iron in this specimen, is 45.64 per cent.

Iron Ore from Madison Furnace, Clarion county, (Buhr-stone ore.)

DESCRIPTION.

Externally cellular; interior compact: color, mass dull brown—of surface, ocherous; aspect siliceous.

Composition in 100 parts:

Silica and insoluble matter,	7.7
Alumina,	3.6
Peroxide of iron,	76.1
Lime and magnesia,	traces.
Water,	12.5
	99.9

This specimen contains 53.27 per cent. metallic iron.

Bog Iron Ore from Smullen's Furnace, Venango county.

DESCRIPTION.

Soft, earthy, pulverulent; color, rich brown yellow; finely powdered, color more brilliant—Bog ore.

Composition in 100 parts:

Silica and insoluble matter,	3.8
Alumina,	a trace.
Peroxide of iron	80.12
Oxide of manganese,	0.50
Water,	13.00
Organic matter,	2.00
	99.42

This specimen contains 56.07 per cent. metallic iron.

Bog Iron Ore from Hickory Furnace, from M'Cullum's bank, Butler County.

DESCRIPTION.

Brittle, earthy mass; containing thin plates of imperfectly crystallized hæmatite; color, bright cinnamon brown—Bog ore.

COMPOSITION IN 100 PARTS:

Silica and insoluble matter, ...	4.8
Alumina, ...	a trace.
Peroxide of iron, ...	78.6
Oxide of manganese, ...	0.4
Organic matter	2.0
Water, ...	14.0
	99.8

This specimen contains 55.02 per cent. metallic iron.

Iron Ore from Bear Creek Hill, Blossburg, Tioga county.

DESCRIPTION.

Color, mottled, reddish and grey; structure, compact, granular, oolitic; in some parts crystalline.

COMPOSITION IN 100 PARTS:

Carbonate of iron, ...	44.79
Peroxide of iron, ...	8.41
Carbonate of manganese, ...	0.88
Carbonate of magnesia and a little manganese	1.99
Alumina, ...	0.34
Silica and insoluble matter, ...	37.28
Water, ...	6.23
	99.92

The proportion of metallic iron in this specimen is 27.05 per cent.

Iron Ore from a part of the same bed with the above—Blossburg.

DESCRIPTION.

Occurs in elongated nodules; color, dingy brown externally—ochrey within; breaks by concentrive layers; soft and somewhat earthy; speckled; showing a tendency to an oolitic structure.

Composition in 100 parts:

Peroxide of iron,	26.69
Oxide of manganese,	0.32
Magnesia with a minute trace of manganese,	0.44
Alumina,	1.88
Silica and insoluble matter,	59.36
Water,	10.52
	99.21

The proportion of metallic iron in this specimen, which is a fair average of the class of ores to which it belongs, is only 18.51 per cent.

Section XI.

Analyses of Iron Ores from the Middle Secondary Red Sandstone Formation.

Magnetic Iron Ore from Daniel Feglie's mine, Boyerstown, Colebrookdale township, Berks county.

DESCRIPTION.

Color, dark dull grey, approaching black, with glimmering crystalline points; powder, black; shows a very slight effervescence by an acid; contains some green chloritic clay; acts on the magnetic needle; occurs in a vein in the red shale, near its contact with the primary rocks of the South Mountains.

Composition in 100 parts:

Magnetic oxide of iron,	86.67
Alumina,	1.36
Carbonate of lime,	0.80
Magnesia,	2.60
Silica and insoluble matter,	7.72
Water,	0.80
	99.95

The proportion of metallic iron in this ore is 62.22 per cent

MAGNETIC IRON ORE from the Warwick mine, near Morgantown, Berks county.

DESCRIPTION.

Color, black; lustre, metallic, but rather dull; contains numerous cavities, the walls of which are coated with ferruginous and talcose matter, and with perfect crystals of oxydulated iron, in rhombic dodecahedron's the ore possesses magnetic polarity.

COMPOSITION IN 100 PARTS:

Magnetic oxide of iron, ...	97.61
Alumina, ...	a trace.
Silica and insoluble matter	1.69
	99.30

The proportion of metallic iron in this specimen, is 70.19 per cent. No titanic acid could be detected in it.

MAGNETIC IRON ORE from Cornwall mine, Lebanon county.

DESCRIPTION.

Nearly black; aspect dull, with brilliant points; somewhat cellular; the little cavities containing small oxtohedral crystals of the magnetic oxide. They contain also a whitish asbestiform mineral. The ore possesses magnetic polarity. The water which it shows by analysis, is probably, only hygrometric.

COMPOSITION IN 100 PARTS:

Magnetic oxide of iron, ...	97.99
Alumina, ...	0.84
Silica and insoluble matter, ...	0.24
Water, ...	0.12
	99.19

This specimen contains 70.34 per cent. metallic iron.

SECTION XII.

Analyses of Cast Irons.

CAST IRON, manufactured from the fossiliferous ore of Montours Ridge, near Bloomsburg, Columbia county, at Esther Furnace.

DESCRIPTION.

A full grey soft iron, uniformly and rather coarsely crystaline.

COMPOSITION IN 100 PARTS:

Pure iron,	96.100
Silicium,	0.100
Aluminium,	a mere trace.
Manganese,	0.224
Corbon,	3.500
	99.924

CAST IRON manufactured at M'Nichols Furnace, near Kittaning, from the Buhr-stone ore of Armstrong county.

DESCRIPTION

A soft grey metal, of an uniform, well developed crystaline grain.

COMPOSITION IN 100 PARTS:

Pure iron,	89.63
Silicium,	5.44
Aluminium,	0.65
Manganese,	0.12
Carbon,	3.90
Phos. and sulphur,	traces.
	99.74

MISCELLANEOUS SUBSTANCES.

Analysis of a *Cadmia*, or incrustation on the in-walls of Mary Ann Furnace, belonging to Whitehill and Ellis, Cumberland county.

COMPOSITION IN 100 PARTS:

Oxide of zinc,	92.48
Oxide of lead,	6.48
Peroxide of iron,	1.00
Carbonaceous matter,	a trace
	99.96

It manifested scarcely a trace of either sulphur or manganese, nor could oxide of cadmium or any other metallic matter, except those shown above, be detected. Incrustations of this nature are not unfrequent in furnaces, and when originally noticed, received the name of cadmia.

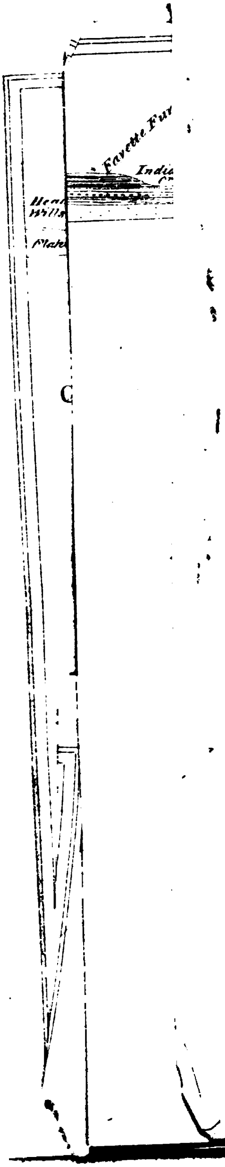
CONCLUSION.

Besides the extensive suite of iron ores here presented, we have analysed an equally numerous series of Coals and Limestones. The relation which these several substances mutually possess, as the three great essentials in the manufacture of iron, renders the precise determination of their chemical nature in each instance, a point of high practical importance to a leading branch of our domestic industry. I am, therefore, conducting a systematic chemical investigation, into the properties of all our ores, fuels and varieties of flux employed, intending to extend the inquiry to the several kinds of cast and maleable iron which our State produces. As much preliminary labor is to be encountered before this portion of our researches will be in a condition for publication, I shall postpone all general conclusions connected with the several circumstances affecting the quality and quantity of iron afforded by different ores, until the opportunity is furnished me for discussing this subject at large, in the pages of my final report. Let me, in the mean while, however, allude to one obvious and important fact, the discrepency in the amount of iron here shown to exist in our ores, compared with that which they produce when smelted by the methods in common use. With a few exceptions, the charcoal furnaces of this State do not get from the ore more than about 40 per cent. metallic iron, and many, not more than 33 per cent.—whereas, it appears from the foregoing analyses, that a large class of the ores employed, contain more than 50 per cent. of metal. This serious waste is mainly attributable, I conceive, to the use of furnaces of too small a size, to too weak a species of fuel, but especially, to too feeble a blast: circumstances all tending to cause a heat insufficient for the thorough reduction of the ore.

Respectfully submitted,
HENRY D. ROGERS.

PHILADELPHIA, *February*, 1 1840.

FIFTH ANNUAL REPORT



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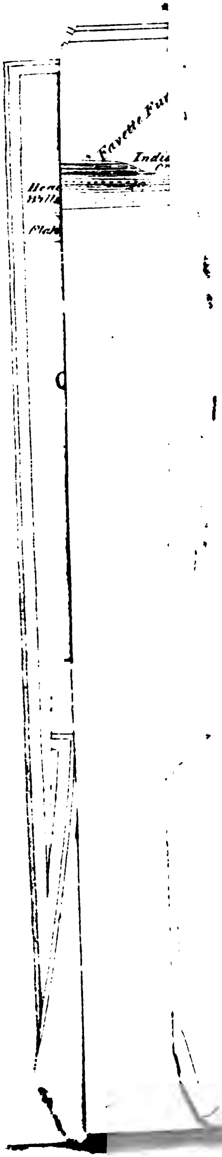

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FIFTH ANNUAL REPORT

ON THE

GEOLOGICAL SURVEY

OF

PENNSYLVANIA.

BY HENRY D. ROGERS,
STATE GEOLOGIST.

HARRISBURG:
JAMES S. WALLACE, PRINTER.
....
1841.

REPORT.

To the Secretary of the Commonwealth:

Sir:—In compliance with the Act of Assembly, requiring the State Geologist to submit to the Legislature, an annual account of the progress of the Geological Survey, I beg leave to present the following Report:

From the middle of April until about the same period in November, the active field operations of the survey were diligently prosecuted; the explorations lying chiefly in parts of Monroe, Northampton, Lehigh, Schuylkill, Berks, Lebanon, Dauphin, Northumberland, Perry, Mifflin, Franklin, Huntingdon, Bedford, Somerset, Cambria, Fayette, Westmoreland, Centre, Clearfield, Venango, Erie, Crawford, Mercer, Butler and Greene counties. Though the detailed examination of several of these counties is yet to be completed, a considerably larger area of the State, was minutely examined, than during any former season.

Guided by the previously acquired insight into the stratification of the rocks, and the true relative position of their contained mineral beds, and assisted by increased experience and skill, on the part of those engaged in the survey, in detecting and tracing the more obscure deposites, we have succeeded in bringing to light much that was before entirely unknown, and settling many points that were doubtful in the economic geology of several of these districts. Thus, where hitherto, no accurate clue had been discovered for tracing particular strata, we have been able, not only to recognize them by their surface indications, but also to determine the exact place they occupy in the series. By pursuing the work on this plan, we shall, particularly on the completion of the survey, when a full description of our geology can be rendered clear, by reference to suitable maps and drawings, furnish to the practical explorer, many useful rules to guide him in his discoveries; while the chemical examinations, now in active progress, will have accumulated a vast body of valuable facts, showing the true composition, and thereby the exact economic value of our numerous minerals in all their important varieties.

To state more in detail the extent to which the survey has been pursued, in the various sections of the State, I shall, for the sake of convenience in description, adopt the division into districts, proposed in my former annual reports.

In the first district, embracing that portion of the State which lies south and east of the Kittatinny valley, the field researches consisted chiefly of a careful revision by myself, of some of the observations made by members of the corps during former seasons. Though I have now in my possession, full details illustrative of the structure and mineral wealth of this diversified region, yet there remain a few rather intricate neighborhoods to be examined before a systematic account of its geology can be safely published.

In pursuing the investigation in the second district, comprising the country between the South mountain and the Allegheny mountain, and between the Delaware and Susquehanna rivers, I had the valuable aid of Messrs. Charles B. Trego and Peter Lesley, Jr., whose previous researches in this and adjoining parts of the State, qualified them to assist in unfolding its intricate geology. Mr. Trego examined the Kittatinny valley, devoting the earlier portion of the season to the exploration of that part of it which ranges from the Delaware to the Susquehanna, comprehending most of Northampton, Lehigh, Berks, Lebanon, and Dauphin counties. In this belt of country, particular attention was bestowed upon that tract, so important for its iron ores, which skirts the southern side of the valley near the Lehigh river, and traverses Northampton and Lehigh. The recent establishment in that neighborhood, of extensive iron works for smelting the ore, by the aid of anthracite coal, has rendered the question of the quantity and quality of all the accessible ores of this belt, of not merely local but general interest. In this view of the subject, some of the veins of magnetic iron ore, belonging to the range of hills south of the Lehigh, investigated by Mr. Boye, with much care and success upon a former occasion, also received attention. Aware of the useful bearings upon both the iron and coal interests of eastern Pennsylvania, of every discovery which may cast any light upon the laws according to which nature has distributed the rich ores of this favored valley, every exertion was made to detect them by their surface signs, and to trace their relation to the neighboring strata, throughout the whole extent of the valley to the Susquehanna.

Apprized likewise of the growing demand for lime as a manure, particularly in the lower country, accessible to the Delaware division of the State canal, it was deemed advisable to examine and collect for analysis, the limestones of various extensive quarries, situated near the river below Easton, that their comparative adaptation to agricultural uses might be accurately estimated. Numerous specimens of hydraulic cement, found in many situations in the limestone belts of this region were also preserved for similar examination.

The latter portion of the season was spent by the same gentleman in the northern part of Dauphin, the southern part of Northumberland, and the adjoining corners of Schuylkill and Columbia counties, in defining and tracing the strata which extend between and around the western points of the several anthracite coal basins, keeping in view the double object of detecting and identifying the mineral deposites of the region, and of collecting topographical details for a correct geological map. These observations were extended into some portions of the coal fields themselves, where much had been already accomplished towards a geological map of the several basins, and were made to include likewise, the region of Montour's ridge, where these features of the surface afford so important a general guide to the range and distribution of its invaluable beds of iron ore. Some examinations, preliminary to more thorough researches to be undertaken hereafter, were made among the coal beds and layers of iron ore at Wiconisco, Raush Gap and Shamokin, where data were collected with the view to show the number, thickness, and relative position of these deposites.

To Mr. Lesley was assigned the long, comparatively narrow belt of country, embraced between the southern base of the Kittatinny or Blue mountain on the south, and the range called the second, mahoning and Pokono mountain, on the north. In the exploration of this region, his attention was directed closely, and with much success, to the physical features of the region, as furnishing an important key to its geological structure. The several axes of elevation, their number, course, and relative positions to each other, were subjects of study, as casting light on the range and distribution of the upheaved formations. Assisted by this method of examination, the limits of each great stratum, or formation, were traced, and the requisite observations made, by which to delineate with exactness their respective areas on the geological map. These investigations were extended from the Delaware to the Susquehanna.

After examining a section of all the strata of this belt, exposed along the valley of the Little Schuylkill, with a view to carry out some researches of the previous year, the exploration advanced to the Lehigh, and thence through Monroe county, to Stroudsburg, in which vicinity some time was occupied, in arranging the intricacies connected with the geological relations of the limestone layers, near the base of F. VIII., and in settling the question of the presence or absence of formations VI. and VII. Terminating these enquiries in the neighborhood of the Delaware, the part of the belt stretching from the Schuylkill to the Susquehanna, was next traversed with similar views, and important corrections made in some researches commenced here in a former year. Much credit is due to Mr. Lesley, for the faithful and laborious manner in which he has unfolded the geology of this occasionally complicated zone of country, and for the accurate and neat map which he has constructed of its formations and topography.

The third district, or that embraced between the South mountains and the Allegheny mountain, and between the Susquehanna river and the southern line of the State, was the field of much minute and laborious research. The details of the exploration were confided to my assistants, Alexander M'Kinley, Esq., and Doctors Henderson and Jackson. To Doctor Henderson was assigned the task of developing the complicated geology of that part of our mountain chain, lying between the Kittatinny valley on the S. E. and the Shade mountain, Blue Ridge, and Black Log mountain on the N. W., embracing the counties of Perry, Juniata, and parts of Union, Franklin and Huntingdon. I must here testify, to the able and successful manner in which this gentleman has unravelled the complicated structure of this difficult region, and depicted its interesting geology, in a new and accurate topographical map of his own construction.

He commenced his labors, by investigating the geology of Juniata county, and the south-eastern townships of Huntingdon, which together constitude a very natural belt of formations, limited on both sides by high mountain ridges. Taking up the exploration at the Susquehanna river, he advanced to the south-west into Bedford county, through the line of country, bounded by the Tuscarora mountain on the S. E., and the district examined by him during the previous year, in Mifflin and Huntingdon counties, on the north-west. The latter part of the season was spent in an equally systematic investigation of the diversified surface, included between the Tuscarora mountain and the Cumberland or Kittatinny valley, taking in the whole area of Perry, and the north-western side of Franklin counties. In conducting these surveys, it was our object to trace, as minutely as practicable, the limits and range of the several formations, through a careful study of the numerous parallel anticlinal axes, which are intimately connected with their distribution. Another object was to observe the gradual change of type in the several formations, and thereby to ascertain, with more precision, what clue was applicable, in each district, for tracing the several included beds of useful minerals. To accomplish these purposes more effectually, and to give the most simplified expression of the results of our researches, it was found important to construct, as we proceeded, a detailed geological map of the whole region. Though this was a task of considerable difficulty, owing to the gross inaccuracy of all the published topographical maps of the district, and though it was necessary to compile ours almost exclusively from original materials, yet, from skilfully taking advantage of the close dependence of the topography, upon the geological structure, Doctor Henderson has been eminently successful in producing an accurate and neat geological chart of the whole field of his operations. Besides this map, numerous sections exhibiting in profile, the stratification of the district, have been constructed.

To Mr. M'Kinley, was allotted the examination of the district included between Tussey's mountain and Sideling hill, extending from the Juniata river to the Maryland line, and embracing the valuable, but intricate coal field of the Broad Top mountain. In the prosecution of this arduous piece of research, he was occupied throughout the first three months of the season, in making a large collection of facts, towards a full description of the geology and topography of this belt of country. Though entirely successful in identifying and tracing the various formations, and mineral belts of every other part of this mountainous tract, Mr. M'Kinley, notwithstanding his long practice and tried skill, encountered much difficulty in developing clearly the confused stratification of the coal measures of the western half of Broad Top. This arose in part from indistinctness in the mineralogical features of the several strata, comprised in this part of the formation, in part from the fewness of natural and artificial exposures, and also, in part, from the number of abrupt axes of elevation which give to the beds various unexpected positions, and efface all bold and prominent marks upon the surface, by which we are accustomed, in other regions, to identify and follow particular deposits. These difficulties can only be surmounted by our causing the several beds of coal and other strata, to be exposed by a series of systematic diggings, made at various points judiciously selected, upon the plan adopted by us in the coal basins N. W. of the Allegheny mountain.

A general sketch of the topography of the Broad Top coal region, was given in my last annual report. The south-west portion alone, possessing any well marked features of the surface calculated in the absence of the mining operations recommended, to elucidate its geology, the investigations for the present were more particularly directed to this portion of the general basin. It is intersected by several deep transverse ravines, which divide the general table land into short ridges and insulated knobs. These ravines are watered by several considerable streams, the chief of which are Trout run, emptying into the Juniata, a short distance above Hopewell Furnace, and Six Mile run discharging itself into the same, two miles below. Between the latter stream, and a branch of the former, are the high rounded summits known as Round Knob and Blue Knob, and between the two branches of Trout run, lies the elevated point called Swartz's ridge. These are the only conspicuous features in the basin, which serve as a clue to its geological structure, for most of the table land of Broad Top, is a high irregularly undulating surface, deficient in those topographical outlines which mark the stratification. After various attempts to determine the number and course of the several anticlinal axes that traverse this region, a knowledge of which would prove the best guide by which to identify the mineral beds, the examination was abandoned as impracticable, until the funds of the survey would authorize, during another season, our employing a skilful miner to open the coal at numerous points where indications of it exist.

The coal seams at present developed, are at points far apart, while the exposures are too few and indistinct in the intervals, to justify any attempt at referring them to their relative positions in the series, or tracing them through their constantly changing dips into other parts of the basin. Thus, on Six Mile run, the thick coal seam, known as Riddle's vein, is opened a little more than a fourth of a mile from the river, but we do not meet with it again, until we recede from the river, about three miles and a half, where we recognize it at the mine of Messrs. Loy & Patterson, though the evidences from the dip of the rocks in the intervening tract, convince us that it must rise to the surface, in one or more localities between the two places mentioned. On Trout run, it has not been found within three miles and a half of the Furnace, though at this distance, it is mined by the Hopewell company. Notwithstanding this, there occur indications of coal, probably of the same seam, within one and a half or two miles of the furnace, up the run, but the only means of definitely identifying the coal, at these intermediate places of out-crop, is by calling in the aid of some practical miner, whose assistance we hope to have, when completing these researches another season.

That part of the third geological district, which is included between Tussey's mountain on the east, and the Allegheny mountain on the west, was examined with much diligence and skill by Dr. Jackson, who carried his researches from the neighborhood of Sarah Furnace, in Bedford county, where he had terminated his explorations the previous season, to the Maryland line. The formations lying at the base of the Allegheny mountain were first studied, and then the others in the descending order. Formation IX., at the foot of the Allegheny, was minutely examined in all the ravines, and other natural exposures, in the hope of finding that important belt of iron ore which follows the lower layers of this rock in a corresponding situation in Lycoming and Clinton counties. Though we had already ascertained that the ore was wanting in that part of the formation which crosses Centre and Huntingdon counties, there was a faint hope that it might reappear, as such beds often do, in Bedford, but the minute observations made, have failed in detecting any indications of its existence.

The calcareous and ferruginous beds, near the bottom of the next inferior stratum, F. VIII., so abundantly developed in some other sections of the State, were next carefully sought for, but the valuable iron ore, extensively distributed with this formation in Mifflin, Juniata, eastern parts of Huntingdon and Bedford, and in Franklin, could not be discovered, and the useful cement layers seen in Clinton and Lycoming were ascertained also to be absent. The only representative found of these beds is a dark slate, in the corresponding part of the formation.

The strata inferior in position to F. VIII., containing important minerals, received particular attention. The *fossiliferous iron ore* of F. V., now ascertained by us to range in so many belts through the Appalachian chain of the State, was carefully traced, in association with the stratum enclosing it, and found to extend the whole way to Maryland.

Besides these explorations, intended to bring to light the mineral wealth of the district, observations were systematically made, with a view to the construction of a correct geological map, and sections, by which to exhibit more plainly the true structure of the region, and the position, range, and distribution of its rocks, with their included minerals.

A large portion of the fourth district, or that which lies between the eastern base of the Allegheny mountain and the western foot of Chesnut ridge, and its prolongation to the N. N. E., and between the west branch of the Susquehanna and the Sinnemahoning on the N. E., and the Maryland line on the south, was this year explored in detail; and, notwithstanding the wild character of many parts of its surface, with very considerable success. In this particularly arduous portion of the survey, I owe much to the zeal and untiring energy of Mr. James T. Hodge, whose familiarity with the methods of research requisite in a wooded country—acquired during former seasons, in some of our northern counties, and, previously to this, during two years in the wilderness of the State of Maine—qualified him with the species of skill particularly wanted in this department of the survey. Mr. Hodge was assisted by the persevering labors of Mr. Townsend Ward, throughout the whole campaign, which lasted more than seven months, and, by the efficient co-operation of Mr. Lesley, who joined the party upon the termination of his duties in the second district, in the month of July. Though a tolerably minute reconnaisance of several sections of this district, especially in Somerset and Cambria, had been already made in the summer of 1838, by Messrs. Trego and Ward, I found it indispensably necessary, to a full understanding of its structure and rich mineral resources, to carry on the exploration in a more methodic way, by the aid of a party of assistants and miners, provided with tents and other equipments essential to an uninterrupted residence in the woods. I therefore placed under the charge of Mr. Hodge and his associates, three skilful miners, whose business it was to expose, by judiciously conducted diggings, the outcrop of all beds of coal, limestone, iron ore, or other materials, either obscurely indicated on the surface, or merely inferred to exist by previous measurements of the adjoining rocks. By this combination of scientific research, with practical explorations, the true position of nearly every mineral band in the district has been established, and the number, thickness, quality, and distance asunder of the various beds, definitely ascertained in numerous localities, so as to afford a clue to the mineral resources of every important neighborhood in the several basins comprised within the region.

The operations of the season were commenced in the first narrow coal basin lying immediately N. W. of the Allegheny mountain in Centre county, resuming the investigation on the head waters of the Tangascootac and Beach creeks, where the close of the previous season had arrested it. This basin was explored south-westward into Cambria county. The second and parallel basin of the West Branch, was likewise carefully examined, commencing in the neighborhood of Hyner's run in Lycoming, and tracing it by Karthaus, to the head waters of Big and Little Clearfield creeks.

Explorations to be hereafter extended to the south-west, were next commenced in the third basin, on Bennett's branch of Sinnemahoning; after which a fourth basin, the next in order towards the N. W., lying near the sources of Little Toby creek, was likewise examined. Important discoveries of coal seams and beds of iron ore were effected, in the two last basins; those on Bennett's branch having already resulted advantageously to the proprietors in the neighborhood. The investigations of the season were next extended into the coal fields, which occupy the southern half of Cambria, the whole of Somerset, and the eastern townships of Westmoreland and Fayette. In this part of the district likewise, the field researches have resulted in the development of many important discoveries, not confined merely to the disclosure of beds of coal, iron ore, limestone, fire-clay, &c., in localities where they were previously unknown, but establishing conclusions respecting the range and distribution of these mineral beds, throughout the several basins which they occupy, calculated to be lastingly useful to the region. A revision of certain points, still somewhat in doubt, and an application of the same methods of research here applied, aided by the clue procured by this year's work, to the unexplored portions of the same basins, and to the great basin of the Monongahela and Allegheny rivers, during one remaining season, will, it is believed, make clearly known every bed of the least importance, belonging to any of the wide bituminous coal fields of the State.

The operations in the fifth district, which comprehends all that portion of the State lying west of Chesnut ridge, and the eastern boundary of Armstrong, Clarion and Venango counties, were, during the past year, confined principally to Erie, Crawford, Mercer and Butler, in the north-west, and to Greene county, in the south-west. The difficult task of making a systematic and detailed exploration of the obscure, but valuable coal field of Mercer, Crawford, and western Venango, was allotted to Mr. Harvey B. Holl, who, by bringing to the investigation much previous practice and skill, in minute research, succeeded beyond my hopes, in establishing a clue to the stratification of this portion of our western coal measures. Baffled during two previous seasons, in my efforts to ascertain the true order of superposition of all the lower coal measures as they appear in Crawford and Mercer, the success which has attended the past season's researches, to which those of former years greatly contributed however, is particularly gratifying. Though the closing in of the year arrested us in the work of identifying and tracing out all of the mineral beds of the series by the clue discovered, yet much was done towards unfolding accurately the position of the mineral treasures throughout Mercer, Crawford, the south-western corner of Venango, and the central tracts of Butler. And I confidently anticipate being able, with an adequate corps employed for one more year, to extend the exploration throughout all the adjoining counties, so as to place us in complete possession of the geology of the whole western district of the State. The key to the stratification which we have now secured, will enable us to open up whatever remains yet obscure in the resources of all those tracts, which have not yet been minutely traversed, and we shall apply ourselves during another season, under highly advantageous circumstances, to the exploration of the remaining portions of the counties mentioned, and also, to that of Warren, Venango, Clarion, Armstrong, Westmoreland, Fayette, besides portions of Greene, Washington, Allegheny and Beaver, parts of all of which yet remain to be examined.

Those sections of Greene and Washington counties, which have been unavoidably omitted during former years, were surveyed in considerable detail, in the three latter months of the past season, by Mr. M'Kinley and Doctor Jackson, who succeeded in establishing, with sufficient precision, the true order and thickness of all the strata overlying the Waynesburg coal seam, and in tracing their range and outcrop throughout the central and western portions of Greene, and the adjoining parts of Washington. Both of these counties, however, should receive some further examination before that precision can be imparted to the description of their resources, which the practical purposes of the survey, and the reputation of the State demand.

The business of compiling, chiefly from our own original observations, a series of new maps, embracing the more intricate topography of the mountainous districts of the State, has been diligently and steadily pursued during the past year. These maps are on a larger scale than the present map of the Commonwealth, many of the grosser errors of which they will rectify, while they will constitute an essential basis for the geological map, intended to elucidate my final report. Another year in the field, will suffice to complete all those observations intended to exhibit the more complicated portions of the geography and geology of the Appalachian chain. When published, they will prove an indispensable accompaniment to the detailed description of the mineral wealth of the State, besides embodying much that is new, towards an improved topographical map of Pennsylvania.

The draftsman of the corps, Mr. George Lehman, whose duty it has been to sketch from nature, the more striking points in the picturesque scenery of the State, and to delineate by his admirably faithful pencil, all those features of the surface, and the stratification which might assist in elucidating the descriptions hereafter to be given, of both the topography and geology, has executed his work of the last year with much ability and success.

Numerous specimens, comprising a large collection of ores, coals, limestones, cements and other minerals, designed for the State cabinet, have during the last year, been gathered in the various districts where explorations were conducted. These are now undergoing a careful classification, a portion of our winter's duty being to open and arrange them, that they may be as accessible as possible, for chemical analysis, and for consultation by myself and assistants, while writing our descriptions of the geology. My practice has been to classify them temporarily, as they have been collected from season to season, foreseeing much useless consumption of time, from any attempt towards a final arrangement of the cabinet, still incomplete in nearly all its parts, until the last season's gatherings shall have been added. Upon the termination of the field work, when the collection will have been rendered entire, the requisite analyses finished, and the final report written in reference to it, then I conceive, will be the time to place the whole at the seat of Government, so arranged, as to furnish in miniature as it were, a complete picture of the geology and mineral wealth of the State.

To put it at present in a position inaccessible to myself and my assistants, would be seriously to interfere with the chemical branch of the survey, to prevent the wished for precision in our mineralogical descriptions, and frustrate in fact, any supposed advantage to the public, by presenting it incomplete, and before the publication of the final report, which alone can render it of any value for reference.

In the laboratory of the survey, a very extensive series of chemical analyses, embracing all the varieties of our iron ores, coals, cements, limestones, &c., from many localities in the State, have been executed. These researches are conducted by Dr. Robert E. Rogers and Mr. Martin H. Boye, whose successful performance of their difficult and engrossing duties, has already redounded much to the usefulness of the survey. By these chemical labors, the exact composition of every mineral of any importance in the State will be ascertained, so as to place beyond doubt, the true value of each variety, and shew its adaptation to the arts and to agriculture.

Allotting the examination of the several divisions of the State, in the manner here mentioned, to the different members of the corps, my own time was spent to superintending either in regular rotation, or as the difficulties of the exploration demanded, the operations in each district successively. By this organization, each assistant can devote himself long enough to the study of a given district, to familiarize himself entirely with the local minutiæ of its geology, while the general supervision of the whole by myself, enables me, in cases of doubt and difficulty, to apply to their solution, both my own observations and those of the other members of the corps.

From the foregoing statement of the degree of forwardness to which the geological survey has been carried, it will be seen, that though extensive progress has been made in every district but the northern one, many important neighborhoods remain to be examined. Influenced by an earnest wish, to complete the work as expeditiously as is consistent with the exactness and minuteness in the results demanded by the law, I have so far matured the investigation, as to feel confident of being able to complete all the field researches in another year. The several acts of the Legislature, making appropriations for the survey, cease on the first of April next, five years from the commencement of the work, though they do not require that it shall be then finished. I have deemed it my duty, therefore, to present the above statement of the present condition, and future wants of the survey, that the Legislature may adopt such action as it may deem wise, concerning its completion.

CHAPTER I.

Geology of a portion of the First, or south-eastern district of the State, not hitherto described, embracing that part of the South Mountains, which lies between the Delaware and Schuylkill.

I propose offering in this place, a concise description of the geology and mineral resources of a part of the belt of hills, known in our State, as the South mountains, confining myself to that division of the chain included between the Delaware and Schuylkill rivers. These hills, though of comparatively humble elevation, constitute part of a great mountain system, which extends through New Jersey and New York, under the name of the Highlands; and through Maryland and Virginia under that of the Blue Ridge.

Entering Pennsylvania at the Delaware river, they occur as a broad tract of nearly parallel, but irregularly connected ridges, ranging in the direction of their length from the N. E. towards the S. W. and having an average breadth of from seven to nine miles, until we approach the Schuylkill. These ridges rarely possess a height of more than four hundred or five hundred feet above their adjoining or included valleys; though their bold undulating outlines and the rugged steepness of their slopes, clothed usually with forest, give to their scenery a prevaling mountain character. Inclosed among these hills, as in so many basins, lie several soft and fertile little valleys, the soil of which reposes on the limestone beds of our second Appalachian formation. The materials not only of the well defined ridges, but of the elevated portions of the tract generally, are either primary rocks, belonging to massive and thick bedded varieties of gneiss, or they consist of a white sandstone, the lowest in geological position of our older secondary strata. To the nature of these materials, and to the violence of the uplifting action, to which they have been subjected, we must ascribe the rugged and sterile character of these hills. Owing partly to the greater intensity, in the quarter next the Delaware of the subterranean disrupting forces, partly to the less thickness in this direction of the white sandstone, overlying the primary strata, these latter are here much more extensively developed than they are further westward towards the Schuylkill.

Before entering upon a more detailed account of the spaces occupied by the several formations, constituting the range of hills before us, let us trace the general boundaries of the whole belt and show how it is related in geographical and geological position to the other tracts which confine it on the N. W. and S. E. We shall then be prepared to delineate with precision the situation of the irregular, insulated patches of limestone, sandstone and other materials embraced among these hills.

Geographical range of the rocks of the South Mountains.

Tracing in the first place the south-eastern limit of the tract, we find it to coincide pretty accurately, along its whole extent from the Delaware to the Schuylkill, with the north-western margin of the red shale and sandstone rocks, which spread to the south, so extensively through Bucks and Montgomery counties, and which here overlap and conceal the group of rocks we are about to describe.

At the Delaware river, the boundary in question, passes close to the little village of Monroe, being more exactly marked by a small stream, which flows at the base of the primary hills. Taking a course somewhat west of south, the line runs about three quarters of a mile north of Bursonton; then crossing Durham creek, ranges west-ward to the vicinity of Opp's tavern, beyond which it bears to the north-west, approaching Leitz's tavern, about two miles south of Hellerstown. From this point, the line of division between the two classes of rocks, ranges in a direction a little south of west, until it meets the south branch of Saucon, about half a mile N. W. of Cooperstown. Here turning rather abruptly, and assuming a nearly south-western course to the head of Hosacock creek, which it pursues for some distance, it sweeps more to the west and passes out of Lehigh into Berks, crossing the line not far from the northern corner of Montgomery.

Entering Berks county, the line crosses the Sumneytown road, a short distance to the north-west of Ritz's inn; then taking a course about fifty degrees south of west, and nearly parallel with the Montgomery county line, it ranges north of the northernmost of the two meeting houses, in Hereford township; keeping a little south-east of Mount Pleasant iron mine, and crossing Swamp creek, about a mile above the county line. It next ranges through Boyerstown to Rhoad's mill, on Ironstone creek. Keeping south of the road to Kline's tavern, and curving at the same time westward, and then north-westward, it passes the Manatawny creek, a little below the line of Amity township. From this point the margin of the tract ranges north of west, to the intersection of the Limekill creek and the township road of Oley and Exeter. Here it turns again south-westward to follow a somewhat undulating line to the Schuylkill; crossing in its route Manokesy creek, a quarter of a mile south of Snyder's mill; then passing near a little church, crossing Raush creek, and finally curving round the base of the Neversink hill to the river.

Along the whole of the line just traced, the primary rocks, and the older secondary limestone, where this occurs, are overlaid unconformably by the edge of the middle secondary red sandstone. In several neighborhoods, however, the precise line of junction of the two sets of rocks is difficult to trace, owing to the quantity of soil, gravel, and fragmentary matter lodged near the base of the hills; this is the case, for example, between the south branch of the Saucon and the Hosacock. In other places, which will be alluded to hereafter in detail, the overlying rock is not the ordinary red shale and sandstone of the middle secondary series, but a coarse, variegated, and more or less calcareous conglomerate, identical in geological situation and in aspect with the rock commonly called Potomac marble.

The north-western boundary of the belt of hills before us, corresponding very nearly with the south-eastern edge of the great limestone formation of the Kittatinny valley, taken as a continuous line, begins at the Delaware river, about two miles below the town of Easton. From this point it is a somewhat undulating margin, stretching to the W. S. W., to within two miles of Maiden creek, a tributary of the Schuylkill, where it suddenly curves, to take a direction nearly due south to Reading. In the earlier part of its range, this line coincides almost exactly with the northern base of the Lehigh hills, maintaining thus, from the Delaware to Allentown, a course, parallel to the southern bank of the Lehigh, from which it nowhere far recedes. South-westward from the vicinity of Allentown, the edge of the limestone, bounding the tract, may be traced by Emaus, Millerstown, Metztown, and Walnut-town, to the curve near Maiden creek, already alluded to, where, sweeping south, it passes Solomon's temple, and takes thence the course of the road leading to Reading.

Though the line just traced, marks the general north-western boundary of the South mountains, there occur several small detached hills lying beyond it to the north-west. The longest and most elevated of these is Chesnut hill, near Easton. This, which is properly a spur of the general chain in New Jersey, consists chiefly of primary rocks. Another smaller ridge, consisting also of primary rocks, lies in a bend of Manokesy creek, about three miles north of Bethlehem. A third, still smaller elevation, occupies the bend of the Lehigh, immediately east of Allentown, pursuing for some distance the northern side of the river.

I shall now enter upon some details of the geology and mineralogy of the chain. Following the general plan of description observed in my previous reports, I shall trace each formation from the N. E. towards the S. W., describing the lowest or oldest formations first, and the others in the order of superposition.

At the north-eastern extremity of the tract, occurs Chesnut hill, the spur already alluded to. This, which is but the south-western prolongation of Marble mountain, a spur of the chain lying on the eastern or New Jersey side of the Delaware, starts at the river, and passing immediately to the north of the town of Easton, crosses the Bushkill above Hester's dam, and then subsiding into a long and narrow point, sinks under the limestone near Seip's, about four miles from its commencement. Its rocks, which are well exposed at the passage of the river round its eastern end, consist chiefly of gneiss, its southern flank alone containing other materials, the more interesting being a belt of talc schist, serpentine, and various associated minerals; the most interesting of these are zircon, actynolite, augite, silvery mica, soft wooly asbestos, and fine psuedomorphic crystals of serpentine. The gneiss belongs to the massive granitoid variety, so common throughout the whole chain. Its strata dip at a steep angle towards the S. S. E., but exhibit in many places much contortion, implying the violence of the forces which have uptilted them. The same dip is visible in the beds of the talc slate. The blue limestone of the valley F. II., encircles the base of this hill on every side, except just at the passage of the river.

Chesnut hill presents the mineralogist with several localities, from which beautiful specimens of various mineral species, especially of the magnesian class, may be obtained; a good collection of these was made by Dr. Swift of Easton. The northern part of the ridge, exposes on the river at "the Weygatt," high, overhanging cliffs of a rock of quartz and feldspar, containing veins of epidote. To the south of this, ranging along the southern slope of the hill, is seen a band of serpentine and other magnesian rocks, embedding a great variety of interesting minerals. Next the Delaware, the serpentine is mostly of the yellow sort, containing in places rhombic carbonate of lime, with indurated asbestos, and also, gray carbonate of lime in serpentine. Far up the southern slope of the hill, occurs a mass of semi-crystalline greenish grey augite, including fleshcolored carbonate of lime. Near the serpentine are several varieties of tremolite, some of it in bladed crystals, some greenish. A little to the westward, near Wolf's old quarry, the serpentine abounds with nephrite, some of which is of a beautiful bluish tint, some of a delicate pink hue, and containing small shining crystals of tremolite. A little south of the nephrite, indeed apparently intermixed with it, are several varieties of talc, as slaty, greenish, whitish, and a scaly green kind. Some of the talc is compact, and is mingled with serpentine, and pervaded with white fibrous carbonate of lime.

To the south of this locality, extends another band of coarse quartz and feldspar rock, in which some of the feldspar is reddish. This portion of it contains crystals of tourmaline and sphene. A belt of this rock occurs at the edge of the river, where it is overflowed at high water; it contains a quantity of soft asbestos, filling the joints. About one mile to the west of this point, being on the same southern slope of the hill, and a little west of the Easton and Wind Gap road, a beautiful silvery mica was formerly found in abundance, but is now nearly exhausted. Near this occurs a scaly talc, in which good crystals of zircon have been met with. Close to this spot, and near the spring that supplies the town with water, is found a white, tabular, crystalline tremolite, some of which is minutely dotted with specks of plumbago; a variety of greenish, tabular tremolite is also here. To the westward of this, in a little cleared meadow, were found specimens of a serpentine rock, containing flesh colored and light carbonate of lime; and also irregular masses of tourmaline in a crystalline serpentine. Here, near an old distillery, augite occurs in light green, earthy looking crystals, with well developed terminating faces. Still farther westward, toward the gap of the Bushkill, and a little south of a syenite rock, which ranges through the ridge, we find a large band of tremolite rock, in the fragments of which are seen crystals of grey tourmaline. West of the Bushkill, on the eastern sloping face of the hill, we meet with a beautiful, dark green, variety of serpentine, some of which has delicate streaks of white, probably carbonate of lime and asbestos. This band of rock is in solid beds, some of them several feet thick, and as it promises to prove susceptible of a fine polish, it may become valuable perhaps as an ornamental stone. It is obviously a *stratified* rock, overlying regularly the syenitic belt of the ridge, which here consists chiefly of sahlite, and dips S. S. E., towards the overlapping limestone of the valley. Between the solid beds of dark serpentine, lie thinner beds of a more slaty sort, with distinct bands of micaceous rock, dividing the serpentine and marking the plane or angle of stratification.

Though upon crossing these primary rocks to the northern side of the ridge, we find them near the Bushkill, in such close proximity to the limestone F. II., as to imply the absence of the generally interposed stratum, the white sandstone F. I., yet to the westward of this, a slate is seen, having the appearance of the slaty member of F. I., near which occur asbestoid and talcose slates, probably portions of the same lowest secondary rock. Higher up the hill, the blue limestone occurs in place, and adjoining it we find the gneiss. At the first of the above localities, the limestone in contact with the primary rocks, forms only a narrow tongue or point, running in from the westward, between the main ridge of Chesnut hill, and a smaller spur, which runs out to the Bushkill a little above the new stone mill. This smaller ridge consists chiefly of serpentine and talcose rocks, bounded at a short distance on the north, by the blue limestone. Some of the talc contains cubic crystals of sulphuret of iron, and some of it is interspersed with fine green serpentine, in which chrystals of zircon are said to have been found.

The true direction of the primary belt of Chesnut hill, is a little S. of W. Its more elevated portion terminates a little west of the Bushkill, beyond which the primary rocks are much concealed by diluvium, cropping out however at Seip's tavern. The high land represented on the Northampton county map, as the western prolongation of the ridge, is not strictly a part of it, but a line of limestone knobs occurring south of the true range.

Before proceeding to the main belt of the Lehigh hills, a small insulated ridge met with about three and a-half miles north of Bethlehem, claims attention. It commences a little west of the road leading from Bethlehem to Nazareth, and follows the south side of the Manokesy creek, in the form of a narrow eliptical hill, crossing the stream and terminating near the road which leads from Bethlehem to Mauch Chunk, a short distance west of which road its primary rocks sink away under the limestone of the valley. This ridge, formed of the same rocks as Chesnut hill, in the prolongation of which, moreover, it seems to lie, owes its elevation very probably to one and the same line of uplifting forces.

A third detached ridge, consisting chiefly of primary rocks, lies between Allentown and Bethlehem, immediately north of the Lehigh, and parallel with it. The principal rock in this hill, is a compound of quartz and feldspar, in which, however, are occasional seams of hornblende and epidote. Its northern side is strewed with fragments of yellowish white sandstone, F. I., the strata of which appear in place, dipping gently northward, at the eastern end of the hill, about a mile and a half west of Bethlehem.

The chain of the South mountains, consisting of nearly parallel, though often irregularly united ridges, will be best described by tracing each belt separately. The first group of ridges extends from the Delaware to Saucon creek, where a long, narrow valley, running in a transverse direction entirely across the tract, separates this from the other belts further to the south-west. Restricting our attention in the first place, to the group of hills east of the Saucon, they naturally divide themselves into three ranges; the northernmost, known as the Lehigh hills, commencing at the Delaware below Easton, and terminating near Hellerstown; the middle one, beginning also at the river above Rieglesville, and terminating north of Cooperstown, and the southernmost lying south of Durham creek, and running from the river to Springtown.

The first of these, the Lehigh hills, bounding for some miles the valley of the Lehigh river on the south, commencing in a loop of the Delaware, about two miles below Easton, ranges towards the S. S. W., and gradually approaches the Lehigh, until the primary rocks show themselves on the river bank, about a mile and a half below the mouth of Saucon creek. Near the east branch of this stream, the chain separates, enclosing small tracts of limestone between its spurs. The primary rocks occupy the margin of the river but for a short distance; the limestone, their usual boundary, resuming soon its place on the southern side. This belt of primary terminates near the bridge over Saucon creek, between Shinersville and Fremansburg, the limestone folding round the base of the hill, and extending up the east branch of Saucon. Between this east branch and the main creek, lie two other ridges or spurs, nearly in a line with the chain just mentioned, the southern one terminating east of Hellerstown, and the other further northward. Between them is a narrow limestone valley, which contracts in breadth towards the east, and heads near the little or east Saucon. Though a separate chain of elevated rocks, the northern belt here described, is not entirely detached from the middle range already referred to, a tract of primary rocks lying round the head of the little Saucon, serving to connect them geologically.

In the general prolongation of the chain, but disconnected from the previous set of ridges, by the transverse valley of the Saucon and its south branch, we have the primary rocks extending towards the S. W., through the lower townships of Lehigh and Berks, in a series of nearly parallel spurs, almost to the Schuylkill. In describing the general south-eastern and north-western boundaries of the whole chain through Lehigh, we have already given very nearly the true limits of the primary rocks in that county. This part of the belt is separated longitudinally for several miles, into two parallel sets of ridges, by the upper part of the valley of the Saucon. One of these tracts, lying west and north of that creek, commences at the Lehigh, near Bethlehem, and ranging south of Allentown, and past Emaus and Millerstown, passes into Berks, losing there its character as a distinct zone of hills; the other originating west of the south branch of Saucon, ranges south-westward to the head waters of Perkiomen creek, where it merges westward into the general belt. On both sides of the county line, dividing Lehigh and Berks, the primary hills compose an unbroken tract, having a breadth of about six miles.—Passing still further to the westward, the general chain expands in width, but becomes subdivided by valleys entering it from the south and west; the broad primary tract, being broken into about five spurs or ranges, and the intervals between them, occupied by belts of limestone and sandstone, the latter often forming hills as elevated as those of the gneiss. The northernmost subdivision of the primary, starting from the general belt, in Rockland township, terminates about three miles east of the mouth of Maiden creek, near the head of Dry run. It is bounded on the N. W. by a narrow undulating strip of sandstone, F. I., which, from the neighborhood of Metztown, to Solomon's temple, separates the primary from the limestone of the Kittatinny valley. This tract of the gneiss is bordered on the south by a long, narrow tongue of the same sandstone, starting off from the main mass of that formation, east of Solomon's temple, and running eastward, past Pricetown, as far as Shiffert's Inn. West of Penn's mountain, which consists of the sandstone, and south of the Pricetown range of the same rock, lies another nearly detached tract of the primary rock, bounded on the E. and S. E. in Oley and Exeter townships, by the slates of F. I., and the limestone F. II. The margin of this large patch of primary strata, is made so excessively irregular, by the protrusion into it of the spurs of F. I., as to render it impossible to describe it intelligibly, without the assistance of a geological map. A third spur of the general primary chain, occupies the southern half of Rockland township, between the two head streams of Manatawny creek. A fourth, smaller spur, projects to the S. W., forming the northern corner of Pike township. It is bounded by Pine creek on the N. W., and by another parallel stream, also a tributary of the Manatawny, on the S. E. A fifth, and much larger tract of the primary rocks, fills the south-eastern part of Pike, the north-western two-thirds of Colebrookdale, and the northern half of Earl townships. It is limited on the N. W. and W., by a long narrow curving belt of the sandstone F. I., which follows the eastern side of the tributary just mentioned, and then the main creek. Its eastern border passes through Colebrookdale township, from Perkiomen to Ironstone creeks, making here a gently undulating line nearly parallel with the Montgomery county line. This south-eastern edge of the primary is formed by the margin of the overlapping red sandstone of the middle secondary period, except at a few points, where small patches of the limestone and white sandstone intervene. Between the head of Ironstone creek and the main Manatawny, near Spang's furnace, there extends a small ridge of the lower secondary white sandstone F. I., which separates the primary tract along its southern limit into two divisions. A line drawn from a point on Ironstone creek, about a mile S. W. of Boyerstown, westward to the end of this sandstone ridge, will mark, with tolerable accuracy, the general limit of the primary on the south.

Of the included belts of Limestone.—The delineation of the several narrow belts of limestone, included between the primary ridges, and spurs of this portion of the general chain, will assist us in exhibiting the topography of this rather confused district. Commencing on the north, we have the limestone of the Lehigh, a part of the great formation of the Kittatinny valley, the margin of which we have already traced. Passing down the Delaware, from the mouth of the Lehigh, this tract of the limestone, measured obliquely in the direction of the river, has a breadth of about two miles, showing first a southern dip of about forty-five degrees, which diminishes, then passes into horizontal, and then into a gentle northern dip, showing a synclinal basin. Between the northern dip last mentioned, and the uplifted primary to the south, there are indications of a narrow anticlinal elevation of the limestone, connected probably with a high narrow ridge of the primary which appears on the Jersey Shore. Passing round the end of the first ridge on the Pennsylvania side, consisting chiefly of gneiss and syenitic rocks, we come to a narrow belt of limestone which extends westward from the river, about two miles, occupying a little recess between two spurs of the primary chain. This limestone is quarried near the river, at Ihrie's and at Harman's. A considerable quantity of lime is made at the latter place, which is four miles below Easton, and some of the stone goes down the canal to various points in Bucks county, where large quantities of it are used. Much jaspary chert, with chalcedony and quartz, derived from the limestone, strews the fields about a mile from the river, on Bruch's farm, (late property of J. M. Porter.)

The prevailing dip of the primary strata in the Lehigh hill, is to the S. S. E. at a steep inclination. Between these primary strata and the northern belt of limestone, we find indications, near the Delaware, of the presence of the white sandstone beds of F. I. This formation, if really present as a continuous stratum, must be of inconsiderable thickness. Resting as it does, directly on the violently uplifted primary rocks, its unfrequent appearance at the base of the hills may however be explained in part by the crush it has undergone, and by the mass of transported fragments concealing it from the sight.

The southernmost of the two spurs of the Lehigh hill, mentioned above as bounding the little narrow tract of limestone, forms the northern limit of another larger limestone valley, the southern boundary of which is Frey's run. The limestone of this valley dividing the northern belt of primary rocks from the middle one, heads on Frey's run, about two miles west of the Delaware, the last exposure of the rock being at Stout's quarry, where its dip is northward. The breadth of this tract, measured along the river, is very nearly two miles; here at Uhler's, about five miles below Easton, it is extensively quarried and converted into lime. The strata, which have been tilted into a nearly vertical position, differ much in the quality of the rock in the different layers.

Bounding this limestone valley on the south, we have the broad belt of primary rocks, which I have designated as the middle ridge of the whole mountain chain. The rocks of this range, comprising chiefly massive strata of gneiss and beds of syenite, cross the Delaware into New Jersey, forming a ripple called Rocky Falls. South of this middle primary hill, and north of the sourthern or Durham ridge, which is a prolongation of the Musconetcong mountain of New Jersey, there lies another narrow but rather longer tract of the limestone, occupying the valley of Durham creek. The breadth of this tract of limestone, measured along the river from a point opposite the mouth of Musconetcong creek to the mouth of Durham creek, is about one mile; the upper edge of the limestone, north of the village of Riegelsville, being much obscured by a covering of diluvium, and the lower bordered by the creek, along which it is well exposed, from its mouth to the neighborhood of Springtown. A little west of the old Philadelphia road, and north of that to Springtown, the limestone appears on the south side of the creek, dipping 60° nearly S. The dip is also southern in several places east of Springtown. The existence of a steep southern dip along the south side of this valley, is in strict analogy with the position of the rocks generally in the valleys of the whole south mountain chain, and implies an overtilting of the strata to the north. This *folding* of the beds upon themselves in the synclinal axes of our first great mountain chain, though highly curious, is a prevailing feature from Vermont to Tennessee.

East of Springtown there is a low ledge of sandstone, F. I., lying north of the road, and following the course of the creek in a northeastern direction.

South of the Durham ridge of primary, there occurs another smaller strip of the limestone, bounded on the south by the conglomerate and red sandstone of the middle secondary formation. This small tract shows itself a little west of the river, near Monroe, occupying the south side of a little stream. It is well seen in the quarry of John

Ermst, inclining 75° to a point a little E. of S., and in that of Johannes Kohl, where it dips to the S. E., at an angle of 30°. Its last exposure on the west, is at the old Philadelphia road, where the red sandstone overlaps it.

The next detached tract of limestone which claims description, is that of the Little Saucon, along the valley of which it may be traced, though with rather obscure exposures. The rock shows itself in the creek about half a mile north of Lower Saucon church, near a blacksmith's shop. Further up the creek, it is said to have been dug, but found too slaty for use. Its last occurrence along the stream, is on the premises of John Rinke, near the intersection of the road and the creek, where it is well exposed, and of a good quality. At this place, its strata dip 40° north-westwardly. Ascending the creek beyond this, the primary rocks show themselves, and the country becomes wild and rocky.

The next tract of limestone is that of the main Saucon creek, in the valley of which, it is the prevailing rock, from within a mile of the Lehigh, almost to the very source of the stream. This belt of the secondary rocks, ranging in a N. E. and S. W. direction across the primary tract, separates the group of ridges terminating on the Delaware from the rest of the chain, stretching towards the Schuylkill. Conforming to the general curvature of the valley of the Saucon, the limestone occupies, throughout the greater part of its course, both sides of the creek, and ascends, for a little distance, some of its tributaries. The lowest point at which it shows itself, is about a mile and a half north of Hellerstown, and by the channel of the creek, nearly two miles above its mouth. Expanding soon in breadth to embrace both channels of the Saucon, which here divide to form an island, one part of the tract sweeps eastward, running up between two spurs of the primary, until it terminates in a point about two miles east of Hellerstown. Half a mile east of the town, the limestone is seen dipping to the N. W. A little to the east of this, between two small hills of gneiss, a short belt of the sandstone F. I. appears, the rock resting directly on the primary, and dipping towards the W. N. W. Beginning with the termination of the limestone, east of Hellerstown, the southern edge of the formation will be found running from hence, in a general south-western course, along the southern side of the valley of the Saucon. About the Lehigh county line, a spur of the primary, running down between the main creek and a small southern tributary, insulates the limestone in the valley of the latter, in the form of a little cove, where it is opened in two quarries, belonging to Abel and Flexer. The general margin of the formation follows the northern foot of this spur as far west as the south branch of Saucon, where it doubles round it; the limestone here running eastward to form another little cove between the spur already mentioned and a second small belt of primary to the south of it. The north-western point of the spur includes a small tract of the sandstone F. I. The edge of the limestone now crosses over to the western side of the south branch of Saucon, extends in that direction about half a mile, and then curves back by the south and east until it again meets the stream, where the limestone disappears beneath the overlapping middle secondary rocks. Within the curved edge just traced, is included, therefore, a third small cove of the limestone, lying like the others, between two jutting points of the primary. Coming back now to the general southern margin of the limestone, we trace it from the south branch of Saucon, first westward and then south-westward, along the main creek nearly to its source, about a mile and a half N. E. of Shimer's. From this point, the whole way down the northern side of the valley of the Saucon, the other, or north-western margin of the limestone nowhere departs far from the border of the stream, following the curvatures in its course, with considerable regularity, to the point where we commenced our description, about a mile south of the Lehigh. The limestone of the main belt of the Saucon is quarried east of Hellerstown, as already mentioned; also at a point about half a mile south of it, dipping at both of these places towards the N. W. It is opened also at Upper Saucon church, in a quarry belonging to Jacob Correll, on both sides of the road, where the dip is towards the south. South of the creek, about half a mile from the intersection of the Allentown road with that leading south from Upper Saucon church, occurs Toger's quarry, where the rock dips to the south, as it does at a point north of this, near the creek. Crossing the creek on the road to Allentown, we find another quarry, the strata dipping to the S. S. E.; and another about two miles higher up the stream, at Peter Egner's, a little west of the road which leads eastward from Emaus. Here the dip is gentle, and a little N. of E. Still further up the creek, beyond the Upper Saucon township line, there is a large quarry, owned by several persons. The prevailing dip just here is to the N. E. The last exposure of the limestone is about a mile and a half above this, in a quarry belonging to John Otto and Laurence Stahler. The dip is gentle, and to the S. W.

Upon the south branch of Saucon, the limestone is opened at Peter Moyer's quarry, and at John Beringer's mill, where the limestone, on this tributary, rests in contact with the overlapping red shale and sandstone, it loses its usual clear blue and acquires a light, bluish pink color. In this vicinity the rock is highly magnesian, and would no doubt, be well suited for making a hydraulic cement. The rock exhibits a crushed character, consisting of innumerable small square fragments.

Besides the continuous belts of limestone now traced, there occur, in the region of these hills, several small isolated patches, remnants as it were, of a once widely diffused tract of the formation, the main body of which has been broken up and swept away. Commencing with the easternmost, we meet with one of these at the Bucks county line, at a point about a mile and a half west of Springtown; and about a mile further westward another, where the rock has a dip of 35° to the S. E. and is quarried by Mr. Leitz. These two patches lie embraced in the primary. In Upper Saucon township, south of the creek, and a little west of the Allentown road, we meet with a third, near the top of a primary ridge, where the rock is exposed at Erdman's quarry. The limestone is of the common blue variety, but it abounds in fissures filled with white carbonate of lime. Its proximity to the agricultural district south of it, where no limestone occurs, and its elevated position which facilitates hauling, cause it to be somewhat resorted to. The rock quarried, is sold on the spot at 2¼ cents per bushel, and the lime at 12½ cents. The only other detached localities of the limestone, in Lehigh county, occur in Upper Milford township. One of these is at Daniel Walder's quarry, about one mile S. W. of the uppermost exposure of the limestone on the Saucon. It is near the source of one of the main branches of Perkiomen creek. Another lies in the western corner of the township, half a mile S. W. of Hampton furnace, being also on a tributary of the Perkiomen; and a third, is on the Hosacock creek, on the premises of Abraham Gerrard. The rock here, is in close proximity to the middle secondary red shale and sandstone.

There remains one other tract of the limestone to be spoken of as occurring south of the Lehigh, occupying a recess in the primary belt immediately south of Bethlehem. Commencing on the southern bank of the river, about a mile above the town, the margin which divides it from the primary, runs in a crescent, until it meets the river again some distance below the town. Thus enclosed, it forms properly but a part of the great belt of the Kittatinny valley.

Durham Cave.

Before quitting our description of the limestone, we may devote a few words to a cavern which occurs in this rock on Durham creek. Its position is a little north of the stream and not far from the Delaware. It has a length of about three hundred feet, an average height of twelve, and a breadth varying from four to forty feet. The floor of the cave is not level, but descends as we penetrate to the interior. Its rough walls are covered with few pendants or stalactites. Much of the bottom of this cave is covered with water, the level of which is influenced, it is said, by that of the Delaware. About half way down occurs a narrow lateral cavern, terminating in the form of the letter T. The general direction of the main gallery is S. W. becoming S. towards the remoter end. The rocks show an anticlinal axis about twenty yards S. E. of the entrance of the cave, the direction of the axis and the cave nearly coinciding.

Most of the limestone of the several tracts above described, belongs to the blue varieties of this rock, so familiarly known. It is by no means, however, invariable in its composition, very many bands being more or less magnesian and some so highly so, as to furnish, when properly treated, an excellent hydraulic cement. Occasionally we meet with a somewhat rare and interesting variety, possessing an oolitic structure.* Bands of this are met with above South Easton, and also on the Bushkill, near Wood's coopershop, and again at Squire Kemerer's limekiln, north of Chesnut hill. These oolite beds of F. II. are not unfrequent in other counties of the State; their common position seems to be near the bottom of the formation.

Localities of the Sandstone F. I.

That the white and grey sandstone F. I., the lowest of our secondary rocks, is not a continuous stratum in the belt of the South mountains, where they traverse Northampton and Lehigh, is rendered highly probable by the unfrequent and local manner in which it shows itself. Still we are entitled to consider it as not confined merely to the few scattered points, where it emerges to the day, but as resting in many places at the base of the primary ridges, buried under a deep covering of loose diluvium. We have already referred to various places where it crops to the surface in sketching the limits of the limestone, which, whenever it is present, it immediately underlies. With the exception of a single doubtful locality, it nowhere shows itself near the Delaware, for there are many exposures in this part of the chain where the limestone is seen resting directly in contact with the primary. Going westward, it first shows itself in the localities already referred to on Durham creek, a little east of Springtown, in the ridge bounding the limestone east of Hellerstown, and in the end of the spur immediately east of the south branch of the Saucon. Ascending the Lehigh, the first point where it appears in place, is on the south side of the river about a mile south of the Bethlehem bridge, where it occurs in a thin band, resting on the primary, and dipping northward 20°. It runs in a narrow belt from the road eastward to the Saucon, where it adjoins the lower termination of the limestone of that stream. We have already mentioned the occurrence of the formation on the northern slope of the small ridge of primary rocks occupying the north side of the Lehigh, east of Allentown. It shows itself again not far from this, on the southern side of the river, about a mile below the Allentown bridge, the piers of which have been constructed of it. Here it constitutes but a thin stratum, the limestone in some places lying nearly in contact with the primary. There are but two other localities in Lehigh and Northampton counties. The first of these is near the top of the mountain east of Emaus, where a rather coarse variety of the sandstone is seen dipping with the slope of the mountain, rather steeply towards the W. N. W. The mountain itself is gneiss. The other locality, at Millarstown, exhibits the sandstone as a low ledge at the foot of the mountain, dipping 10° towards a point 75° W. of N. Westward of this, especially in Berks, it increases in thickness and abundance as we approach the Schuylkill.

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* Oolite.—A limestone so named because it is composed of rounded particles, like the roe or eggs of a fish.

Sandstone and Limestone, F. I. and F. II., in Berks county.

The white sandstone which appears in a few detached localities along the north-western line of the South mountains in Lehigh county, begins to show itself as a more continuous formation, after we enter Berks, rising even into high irregular ridges in the south-western part of the chain. A very usual position of the sandstone is upon the flanks and around the extremities of the primary spurs, where it often indeed overtops the gneiss and igneous rocks, which then appear only on the crests of the hills, as low dykes, difficult to trace. Even where the sandstone is best developed, some difficulty attends our tracing it as a continuous formation. This arises from its immediate proximity to the greatly convulsed primary strata, and from its lying so frequently on the declivities of the hills, where its outcrop is much obscured by fallen fragments. The sandstone, where it is subordinate to a larger ridge of primary, often either encircles, at a little distance, the extremity of the spur, lies more or less obliquely across it. Sometimes, even in the middle of a high tract of the sandstone, where no regular belt of primary rock protrudes itself, evidence is perceived of its having reached the surface at certain spots, from the quantity of angular fragments. The sandstone itself offers often great difficulty, in determining its stratification and the true direction of its dip; whole hills looking like mere piles of huge angular blocks, or innumerable fissures and cleavage-joints, traversing the beds, so as greatly to perplex the observer.

Metztown.

Passing from Lehigh into Berks, the first exposure of the sandstone, is at a hill, lying south of the Little Lehigh, and about two miles S. E. of Metztown. Here the rock is chiefly in loose pieces, covering the foot and lower aclivity of the hill. The sandstone also shows itself in place, about one mile south of Metztown, immediately west of the church. Between the visible edge of the limestone, which passes by Metztown and the foot of the primary hills further south, there is a considerable tract of country where no rock appears upon the surface, with the exception of the isolated tract of sandstone, at the church just referred to; a deep covering of diluvium hiding every thing from view. Approaching the mountains from the north, the first rock seen in place, is a white variety of gneiss. This is on the road leading to Hoof's inn. West of this, in Maxatawny township, the limestone is seen where a road crosses the Sacony creek. The sandstone, which shows itself N. E. of the creek, disappears a little south of Grim's mill, the gneiss showing itself on the west side of the stream, between the mill and Hunter's furnace.

The general margin of the limestone, passes about a quarter of a mile north of Walnut-town. About a mile south of this place, on the N. E. of the road, occurs a sandstone ridge, running in a N. E. direction. A littler further south, upon the same road, we observe the outcropping of the gneiss. This gneiss, part of a long belt of primary, averaging about a mile in breadth, terminates at Millar's mill on Dry run. A belt of the sandstone, as already described, flanks it both upon the north and south, the sandstone uniting round the point of the primary, a little east of Solomon's temple. Southward from this last mentioned place towards Reading, the sandstone lies on the east of the road, the whole way to within three miles of the town, where a belt of slate, probably the upper member of F. I., crosses the road. If we here turn aside to the N. E., taking the road to Barnard's mill, (Rothermel's mill on the county map,) we encounter, just at the mill, a low protruded mass of igneous rocks. A little to the N. W. of this point, a small body of limestone has been discovered, south of which, in the sandstone, we may trace a low dyke of syenitic rocks running towards the N. E. East of its north-eastern end, and west of its south-western, occur two other small patches of limestone. The line dividing the limestone of the Schuylkill valley, from the sandstone and slate bounding it on the east, after following the road which leads from Solomon's temple south, suddenly curves to the eastward about two miles north of Reading, reaching, but not crossing, the road from that borough to Princeton. Here, at Rothenberger's inn, turning very abruptly to the S. W., and gradually receding westward from the road last mentioned, it next runs to the Schuylkill, passing through the western side of Reading, leaving thus a triangular tract of the limestone protruded into the general area of the sandstone.

Hills East of Reading.

Penn's mountain, commencing east of Reading, and running in a N. N. E. direction nearly five miles, consists, on its summit and western side, of the white sandstone, F. I., dipping to the W. N. W. Descending the eastern slope of the mountain, we soon encounter the primary rocks, which maintain this position as far to the S. W. as Kesler's mineral spring. This is the termination of a wide belt of primary rocks, chiefly gneiss and syenite, coming off from the general chain to the N. E. with a prevailing S. W. and N. E. direction of the strata. At Spie's church, there occurs a high sandstone ridge in the midst of the primary, being detached from any other tract. Penn's mountain, at its northern extremity, sweeps suddenly to the eastward, jutting between the main belt of the primary around Spie's church, and a narrower tract which crosses the Reading and Pricetown road. North of this last piece of primary, and N. W. of the prolongation of Penn's mountain, are some high sandstone ridges, probably concealing dykes or beds of primary rocks between them. Pursuing the road north-eastward to Millar's inn, we have the sandstone on the N. W., while on the S. E., the hills consist principally of gneiss. Between Millar's inn and Pricetown, the road separates a hill of gneiss on the S. E. from a high short ridge of sandstone on the N. W. Gneiss occurs also about one mile from Pricetown, S. E. of the road going towards Sterner's inn, (of the map.) A sandstone ridge rises at Sterner's inn, on the N. W. side of the road, and extends nearly to the tributary of Manatawny creek, in Rockland township, beyond which, until we pass Roth's mill, all the rocks are primary. Going E. of S. from Roth's mill to Pine creek, we encounter none but primary rocks forming a wide tract. The sandstone, however, shows itself at the spot marked Shiffert's inn, on the county map, appearing *in situ* on the slope of the hill, N. of the road. The rock here is somewhat coarse and of a purplish color. Passing to the S. W. it seems to cross the road.—Descending the creek we meet another ridge of similar sandstone, occupying the W. side of the stream, at a mill designated on the map as Mineder's. Further south, about a quarter of a mile north of Snyder's upper forge, (Udree's forge of the map,) the sandstone again shows itself on a small hill, east of the creek, and again on its western side.

The hill immediately to the S. E. of Sterner's Inn, consists obviously of primary rocks, the surface being wholly covered with their fragments, though no regular outcrop is seen. Still pursuing the road to Oley furnace, we pass diluvium, containing much fragmentary sandstone, until at the creek, close to the furnace, we behold the sandstone in place, dipping steeply on the east side of the stream, to the N. N. W. The rock here is coarse and reddish, and occasionally very talcose. Immediately west of the creek, lies a large hill of syenite, and about half a mile nearer Fredensburg, we come upon the margin of a wide tract of slate, apparently the upper member of our lowest secondary formation, of which the sandstone, hitherto most commonly encountered, is the lower. Nearly two miles N. W. from Fredensburg, on the N. E. side of the road to

Millar's inn, occurs a belt of sandstone, dipping steeply to the N. N. W. Here is an old mine of iron ore to be described hereafter. Beyond this, a sandstone ridge is seen running parallel with the road, about a quarter of a mile on its N. E. side. Between this and Millar's inn, an interval of about a mile, the prevailing rock is gniess.

Let us now trace the line which divides the gneiss from the slate and sandstone F. I., and the limestone F. II., in the northern and western parts of Oley township. About three-fourths of a mile S. W. of Lobach's mill, on Pine creek, we come upon the margin of the limestone, crossing the stream in an E. and W. direction, through the lands of Jacob Keim. The dip here is due S. 60.° To the N. E., and E. of this, the sandstone shews itself in a belt to be presently described. North of S. Peters' mill, (marked Maul's on the map,) runs the edge of the primary, which here exhibits no sandstone interposed between it and the limestone. The margin of the limestone is well seen half a mile W. S. W. of the mill, the rock dipping steeply to the S. S. E. Immediately above this limestone, on the creek, we have the slate crossing the stream just at the road leading to Sterner's inn. The true dip of this last rock is difficult to discover, owing to the obscurity of the divisional lines of the strata, and the abundance of cleavage planes, wholly independant of those which ought to mark the dip, the dubious direction of which leads to some uncertainty respecting the precise formation to which the stratum belongs. Could its beds be seen passing unequivocally under those of the limestone, it would plainly prove itself to be the upper, slaty portion of F. I; if, on the other hand, it should be seen to dip away from the limestone, at the line of contact, no doubt would remain as to its being part of F. III. The margin separating the slate from the gneiss, passes about half a mile N. W. of Fredensburg. Taking the road leading out of Fredensburg, to the S. W., we pass over the slate for nearly a mile and a half, until we cross a little stream, the dividing line of Alsace and Oley townships, where we pass directly upon the gneiss. Ascending the creek by a steep ravine, we pass the eastern termination of the spur of sandstone at Spie's church, already spoken of. East of this spot, the boundary of the slate and gneiss is near Knabb's mill, (Reiff's on the map.) The hills immediately west of the mill, marked Knabb's on the map, and of the road separating Oley and Exeter townships, are strewed with fragments of primary rocks, as far down the creek as the first exposure of the limestone, which is half a mile N. of the road running westward from Oley forge. Following this road, which deflects towards the S. W., we pass across a corner of the limestone tract, and at a short distance west of the Manokesy creek, encounter the common margin of the limestone and the primary. These two formations rest apparently in contact, from the upper point of the limestone, on the Manokesy, below the mill marked Knabb's, throughout a mile and a half towards the S. W. About two miles east of Maurer's inn, the sandstone shows itself in place, between the limestone and the gneiss, on the southern slope of a hill, some distance north of the church. Under this sandstone, is an argillaceous slate, in very thin lamina. Between this and Maurer's inn, the rock is exclusively sandstone, the large double hill N. E. of the tavern, being entirely of this formation. Here a quarry has been established for getting building stone; the dip of the rock is obscure. This ridge of sandstone extends in a north-easterly direction, about two miles and a half towards the insulated sandstone hill, near Spie's church, from which, however, it is separated by more than a mile of primary country. East of the ridge, the rocks are a white variety of gneiss, consisting of quartz and decomposing feldspar, and a syenite composed of feldspar and hornblende, in frequent alternation with the gneiss. Where these rocks abound, the surface is marked by small rounded hills, covered with fertile soil, giving a pleasing aspect to the country. A similar topography is particularly striking in some parts of Colebrookdale township, hereafter to be mentioned. The limestone belt, bounded as we have already said, for the first mile and a half by gneiss, runs afterwards the whole way to the Schuylkill, below Reading, crossing Bishop's creek, about a mile below Maurer's inn, and folding round the southern point of the Neversink hill. From the Manokesy, westward to the Schuylkill, the limestone belt, bordered on the south by the middle secondary rocks, contracts into a narrow zone, a few hundred yards in breadth. On its narrow limit, it dips to the south. Where it crosses the Perkiomen turnpike, three miles from Reading, it shows in a quarry near the road, many beds, of a crystalline, granular structure. Much of the rock at this place is of a dull yellowish white. It dips a little W. of S. It strikes the western reach of the Schuylkill, about a mile and three-fourths south of Reading, where it is overlapped on the south, by the coarse calcareous conglomerate of the middle secondary series. North-eastward, this narrow belt opens into the wide tract of limestone, which occupies much of the eastern half of Oley township. From its southern point on Manatawny creek, a fourth of a mile below the line dividing Amity from Earl townships, the eastern edge of this large tract passes up the Manatawny, and then up its eastern tributary, as high as the line which separates Oley from Pike. Its northern margin crosses Pine creek, about a mile below Lobach's mill. Its north-western corner is at the place marked on the map, Peters's red ochre mine. Its western limit is the eastern boundary of the slate, which occupies a large tract in the western half of Oley. The limit between these rocks runs southward, nearly through the middle of the township, until it strikes the Exeter line a little east of Manokesy creek.

The slate, which we have already mentioned to be most probably the upper member of F. L., spreading from the western edge of the township, (Oley,) eastward beyond Kemp's inn, shows generally a dip to the S. S. E. About a half a mile south of Kemp's tavern, the slate is bordered by slaty limestone, which apparently overlies it. The slate, east of Fredensburg, graduates into slaty sandstone; but south of Rieff's mill, the slate is soft and sectile, approaching in texture to pipe clay. At this and several other places, its strata are intersected by veins of quartz.

I have already referred to the belt of sandstone which occupies the valley of Pine creek. This extends from the neighborhood of Pott's forge, to the edge of the limestone, a mile below Lobach's mill, where, doubling round the point of a wide spur of the primary, it runs eastward, to join the much longer tract of sandstone which follows the Manatawny and its eastern tributary, in Pike township, for many miles. This latter range of the sandstone, commencing near the western corner of Hereford township, crosses the narrow part of District township, and then the whole of Pike, following the eastern side of the Manatawny, nearly as far down as the line dividing Amity and Earl.

Mention has already been made of another tract of sandstone in the form of a ridge or spur, commencing about a mile east of Spang's furnace, and running in a N. E. direction, into the region occupied by the gneiss. At Hill's inn, the limestone is found on the east side of the Manatawny, dipping to the N. W. The sandstone immediately east of this, dips steeply in the same direction. A little north of the Amity township line, the sandstone on the other hand, crosses to the west side of the creek. At the bridge, on the township road, over the Manatawny creek, the limestone, in its upper beds, is striped by reddish ribands. A calcareous slaty sandstone here occurs, precisely similar in appearance to the red sandstone of the middle secondary rocks, of which it may be a detached or outlying patch. About a quarter of a mile below this, on the creek, is the general margin of the middle secondary red shale and calcareous conglomerate.

The southern half of Earl township includes chiefly long hills of syenite and other primary rocks, running in a N. N. E. and S. S. W. direction, having coarse sandstone, F. I., flanking them on their N. W. slopes. Taking the road from Kline's tavern, near the Manatawny, eastward to Boyerstown, the sandstone of one of these spurs, approaching from the N. E., shows itself on the road, dipping 35° S. S. E. At the intersection of the road and the township line of Earl and Douglass, we enter on the margin of a small tract of limestone, overlapped further south by the red sandstone. It crosses to the north of this road. The limestone peeps out at a house laid down on the county map, as Keely's tavern, and shows itself again in a quarry a few hundred yards east of the tavern kept by Mr. Gresh. Near Keely's old stand, the sandstone occurs on the north side of the road, and it again appears N. W. of Gresh's. The limestone to the south of this is overlapped by the middle secondary rocks. East of the limestone, and before reaching Rhoad's mill, we come, in succession, upon white gneiss, syenite, sandstone, and limestone, the latter appearing at the mill. From this point eastward, to Boyerstown, the whole space is occupied by primary rocks, covered on their southern margin, by the middle secondary.

All that part of Colebrookdale township, lying to the N. W., N. and N. E. of Boyerstown, consists exclusively of primary rocks. These form innumerable hills, covered by a deep and rather fertile soil, the whole district presenting, in a succession of undulating outlines, a highly pleasing series of landscapes. The limit of the primary and overlapping middle secondary sandstone, passing through this township, from Rhoads' to the west branch of Perkiomen creek, we have already defined.

A locality of crystalline limestone occurs in the centre of Colebrookdale township, on the N. E. side of a road. The spot is about three-fourths of a mile N. W. of the edge of the middle secondary red sandstone. Between this place and Swamp creek, lie several high hills, covered entirely with diluvium and fragments of sandstone. Hills of this description are common along the line, separating the middle secondary region from the primary hills of the

South mountains. At Swamp creek, we enter a valley, bounded on the N. W. by rounded knolls of the primary, and on the S. E. by the red sandstone (middle secondary.) This valley contains several exposures of limestone. The first of these, is on the west side of the stream, and belongs to Peter Motha. A little N. E. is the quarry of Jacob Oberholz, and beyond this, in the same direction, the limestone occurs on the premises of Henry Stauffer. At the first place, the strata dip N. E; at the second nearly S.

A narrow belt of the white sandstone, F. L, commences just east of the west branch of Perkiomen creek, and runs to the N. N. E., through Hereford township, to the line of Lehigh county. It is bounded on the S. E. by the overlapping red sandstone, and on the N. W. by the gneiss. The white sandstone shows itself on the main road, passing through the centre of the township; the rock dips towards the south. It is again well exposed on the east side of the main Perkiomen creek, where the Sumneytown road crosses.

We find a small insulated patch of the white sandstone in District township, about a mile and a quarter N. W. of Hoof's inn, where it occurs, surrounded by an elevated table land of primary rocks; the sandstone is of a coarse description. Passing from Hoof's inn, south-westward along the west branch of the Perkiomen, we meet another spot where the sandstone undoubtedly exists in place; this is about half a mile from the inn, on the S. E. side of the road. A little west of this, commences on the stream, a narrow valley, extending down to John Rush's forge, where the mountains approaching, close it in. The Mount Pleasant forges are situated near the lower end of this valley. Limestone shows itself a short distance above Rush's mill, (Hunter's on the map,) dipping S. S. W. It is again exposed in two fine quarries, one on each side of the creek, at David Schall's forge, (Thompson's on the map.) In the western of these quarries, the limestone considered the best, is of a dark blue color. According to our analysis, the rock in both localities, is highly magnesian, the composition being in other respects precisely similar; the lighter colored variety, containing if any thing, rather fewer impurities. The dip in both quarries is to the N. W. Near Mr. Rush's house, a little above his forge, there is another spot on a little creek, where the limestone has a slatey composition, and contains sulphuret of iron. Near this, they find a species of nodular chert in the diluvium, which can be shaped into hard but excellent whetstones. The soil has been raked over, and the loose pieces picked out and ground into a square form on a lap driven by a small water power. The whetstones were sold for thirty cents per pound in Philadelphia.

Iron Ores of the Gneiss.

The primary belt contains in several places viens of magnetic oxide of iron. These occur as regular lodes or veins, penetrating the gneiss and other primary rocks almost invariably in a direction coincident with the bearing of the strata. They might be taken, therefore, for interpolated beds, but for the occurrences of occasional branches and other irregularities which establish their intrusive origin. They agree in all their features with the larger and more numerous veins further towards the N. E. in the Highlands of New Jersey and New York.

Iron Mines of the Lehigh Hill.

Beginning with the part of the belt next the Delaware, the first vein we encounter is upon the Lehigh hill, about two and a quarter miles south of Easton, a few rods N. W. of the old Philadelphia road. The rock here is a mixture of quartz and feldspar, with occasionally a little epidote. On the southern side of the ridge, the strata are talcose. The vein of magnetic iron ore lies in contact with a syenitic dyke, consisting largely of green sahlite. This vein was formerly mined, but the work has been long since abandoned. The ore, which is very compact, appears to have a N. W. dip.

Durham Iron Mine.

Another somewhat noted locality, is that of the old Durham iron mine, which is on the top of the hill south of Durham creek, on the old Philadelphia road. This mine has likewise been neglected for many years, nor is it practicable in the present state of the works to ascertain with precision the value of the vein.

On the northernmost of the two primary hills, east of the Saucon, and about a mile N. E. of Hellerstown, a vein of magnetic iron ore shows itself in several places, though the quantity of ore here is probably not great. It is much mixed with quartz, though we obtained some tolerably pure specimens. A syenitic dyke, composed chiefly of sahlite and hornblende accompanies the ore, and seems to have been the chief object of attention to those who have undertaken mining here.

Brown argillaceous iron ore shows itself on the surface in some abundance, on the north side of this hill, near the junction of the primary rocks and the limestone. The appearances of ore are promising on Dillingham's farm, and much fibrous hematite is found on Hartman's, the next farm to the north. An open porous ore, in considerable quantity, is visible in a field on the latter place.

Fragments of magnetic iron ore occur in many places on the surface of the bold hill of primary rocks, south of the Lehigh, at Bethlehem, where some search has been made for it by digging. S. W. of Shimersville, near the east end of the same ridge, a vein of green sahlite, which has been mistaken for iron ore, shows itself near the summit of a hill. Close to this spot, some true iron ore has been found by us, the source of which is probably a little north of the sahlite. Epidote, mixed with iron ore, also occurs here. Further westward, near the summit of the same ridge, magnetic iron ore in a talcose rock is visible, near Shuber's, three miles from Bethlehem; it has not been dug for. The same variety of ore, of excellent quality, is found on the surface, near the top of the northern primary ridge south of Allentown, at a spot a little west of the Philadelphia road. A less magnetic variety is met with on the northern slope of the hill, a mile to the east of the road. Further to the S. W., the magnetic iron ore shows itself in the primary hill, three miles S. E. from Metztown, the spot being a little west of the Philadelphia road. It is on the southern side of the second primary ridge from the north, on lands of Messrs. Trine and Peter Fegely, the line dividing their tracts passing through the mine. The ore occurs in three regular veins, dipping with the adjoining strata, at an angle of 50° to the S. S. E. The southern vein is about a foot and a half thick; north of it occurs a stratum of rock, (gneiss,) eight feet across, in contact with which is the middle vein, separated near its outcrop into two branches, which at a little depth unite into one vein; this is bounded on the north by a stratum of rock about four feet in thickness, and directly in contact with this, is the third or northern vein, having a thickness of two feet. The rock which encloses these several veins, is a coarse regularly stratified gneiss, a mixture chiefly of quartz and feldspar.

Some miles to the south of the above, magnetic iron ore occurs on the border of Colebrookdale and Hereford townships, in the Mount Pleasant iron mines. In the north-eastern excavation, belonging to Isaac Berthou, the ore occurs between syenitic rocks, and is itself a mixture of rotten syenite and magnetic oxide. It is worked open to the air, in a drift ten or twelve feet wide, ranging E. of N. The dip here is 65° and a little S. of E. This mine, in the course of seven weeks of active operations, has yielded seven hundred tons of rich ore. The quality of the ore is however variable. A few hundred yards more to the S. W., is the mine owned by John Landis; it includes two large excavations, one of them twenty feet wide and sixty or seventy feet long, and sixty feet deep, pursuing apparently a regular vein or bed parallel with the strata. The ore removed at various times, amounts to about three thousand tons. The second excavation, bears a little N. of E. from the above. Two other excavations, on property belonging to Peter Disher, occur about two hundred yards W. of S. from these. Here the bed has a nearly east and west direction, and may probably be the same which contains the mines just previously spoken of. This ore, more compact than that of the other mines, is stated to have made a rather redshort iron. The excavations are on a less scale than the largest one on Landis' place.

It would be important at the present day to ascertain, if possible, the causes which led to the abandonment of the magnetic iron ores of the region under review. The ore which supplied the old Durham furnace, in Bucks county, now long neglected, is said to have made an iron of excellent quality. Should it appear that a deficiency of good fuel, not the want of ore, was the difficulty, we may hope to see these localities once more resorted to, now that anthracite coal, so easily had in this neighborhood, proves itself so admirably adapted for smelting those harder ores which require a disproportioned expenditure of charcoal.

Localities of Brown Iron Ore.

Brown or hematitic iron ore, in various forms, is often met with, in connection with the sandstone and limestone embraced in the chain of the South mountains. A usual place for the ore is near the junction of these formations with the underlying primary. Ore occurs in this position, near the border of the limestone, at the northern foot of the Lehigh hills, in many spots. Several excavations have been made about a mile in a direct line from South Easton, on the premises of John Bess. One of these was by a shaft about three hundred yards from his house. It is fifty-five feet deep, the first ten feet being through diluvium, the next ten feet through ore and ore ground, and the remainder of the distance through clay. Two other holes, each forty-two feet deep, were dug about three hundred yards from the above. In one of these, the covering of diluvium was fourteen feet thick, below which occurs the ore. The mining was done by the proprietors of the South Easton furnace, who paid an ore rent to the owner of thirty-seven and a half cents per ton. The geological situation of this ore is probably upon the sandstone, F. I. An unsuccessful excavation was made near the top of the hill, where gneiss and syenite, and other primary rocks were struck. About three miles westward from South Easton, a mine has been opened, at Jacob Woodring's, in a hollow between two spurs of the primary chain. It was not wrought at the time of our examination. The shaft here is said to be ninety feet deep, passing through diluvium and clay for fifty-five feet, before any ore was found. The ore is moderately rich, but contains some manganese. The limestone shows itself on the surface, about three hundred yards north of the ore. Westward of these localities, surface signs of ore are abundant, as at Ihrie's and Brotzman's, half a mile south of the Lehigh. At Brotzman's, where some manganese is associated with the ore, the diggings were made probably too high in the side of the hill, being apparently outside of the edge of the limestone. The ore here is rough and sandy, and contains compact black oxide of manganese in some abundance. A little hill, further west, on the same farm, lying within the limestone, shows a much better ore on the surface. On Richards' farm, in the same range as Brotzman's, but further west, surface ore is quite abundant, some of it being fibrous hematite. The next farm westward, presents the same indications. At the period of our exploration, the Lehigh Crane Iron company, whose works are situated on the Lehigh, three miles above Allentown, were about to commence some shafts on Richard's farm. They have since, it is said, purchased Ihrie's, so that it is now probable that the ores of this neighborhood will be well investigated. Above Richards', the primary formation approaching the river, cuts out the limestone, and consequently, the ore. But the limestone again showing itself higher up the river, a little ore has been dug above Bethlehem bridge, where, however, it is probably exhausted. Pursuing the same line to the S. W., we find an iron mine, (Swartz's,) at present neglected, about three-fourths of a mile S. W. of Emaus. At this spot there is only one mine hole, about forty feet deep. Smelted alone, this ore made a cold short iron, and was therefore usually mingled with other ores, principally with that from Breinig's mine. In some of the specimens found here, no manganese could be detected, though some of the ore has a manganesian aspect. Its geological position is in diluvium, lying near the border of the limestone.

The next locality of importance, is the old iron mine belonging to Oley furnace, nearly two miles N. W. from Fredensburg. At this spot the ore was dug from immediately under an outcrop of the sandstone, F. I., the digging running parallel with it for more than a hundred yards, and being eighteen or twenty feet deep, and eight or ten feet wide. This mine, now abandoned, furnished us some specimens from the side wall of the excavation; these are argillaceous and laminated, and of a purplish red color. A shaft unites the main excavation with another nearly under the first, having about the same direction, but descending more perpendicularly. This latter mine is from three to five feet wide; the wall is of primary rock, chiefly feldspathic and hornblendic gneiss, but sometimes entirely micaceous, and it contains, in certain places, magnetic and micaceous iron ore. The proprietors of Oley furnace propose reopening this old mine, having nearly completed a tunnel now six hundred feet long, intended to reach the lower excavation. The rocks passed through in the tunnel, are gneiss, syenite, hornblende, and micaceous slates.

On Pine creek, in Pike township, some diggings have been made for ore, about half a mile S. E. from Lobach's mill. The ore has the aspect of a talcose slate, charged with the oxide of iron; it has a laminated or rather a fibrous structure. There is a rather large excavation at Boyerstown, belonging to Daniel Feglie. At the time it was visited, the opening was filled with water. The rock accompanying the ore, is a light green soft variety of slate, dipping E. The ore itself is dull black, and contains many crystals of iron pyrites; it is said to have made a coldshort iron, and to contain copper, of which, however, no trace was visible. A short distance W. of S. from the above, occurs another mine, belonging to John Rhodder, where the ore is more compact. Both these localities are connected probably with the middle secondary red sandstone formation.

Middle secondary rocks, immediately bordering the South Mountains.

It remains for us, before quitting the geology of the South Mountain chain, to introduce here a brief description of the formations skirting the southern base of these hills. At Monroe, on the Delaware, a small creek separates the primary hills on the north, from the red sandstone of the middle secondary series. A little spur of syenite, running from N. W. to S. E., is exposed on the south side of the stream, where it breaks off abruptly. Its south-eastern end is overlapped by a thick bed of coarse calcareous conglomerate, forming a high crest nearly at right angles to the direction of the syenitic hill. This calcareous conglomerate is a very heterogeneous rock, consisting of pebbles of every size, some several inches in diameter, and derived promiscuously from all the older adjacent rocks, both primary and secondary. The cement uniting these pebbles is the substance of the neighboring red shale, impregnated with more or less carbonate of lime. A large, and in many cases a predominant proportion of the pebbles, belong to the contiguous limestone, F. II.

This conglomerate, identical with the Potomac marble of Maryland and Virginia, both in its features and geological relations, is here the uppermost stratum of the great middle secondary red shale and sandstone formation, which occupies so large a part of Bucks and Montgomery counties. Conforming to the prevailing N. or N. W. dip of that great series, its strata decline at a gentle angle towards the foot of the primary hills, abutting unconformably against the steeply uptilted strata north of them. At the south-east end of the above mentioned primary spur, we behold some patches of the ancient blue limestone yet adhering, the strata being much contorted, as if from the sudden rising of the syenite. Below the calcareous conglomerate, lies a very hard red siliceous sandstone, sometimes coarse, and containing pebbles, but sometimes very uniformly grained. Beneath this again occur fine grained red sandstone and shales. The calcareous conglomerate soon disappears going westward; no trace of it appearing on the old Philadelphia road, two miles from the Delaware. The next development of the calcareous conglomerate is west of Bursonton, where it forms a small belt running E. and W. across Durham creek. It shows itself again a little S. E. of Opp's tavern, in a low exposure east of the road. Passing Opp's tavern, towards Hellerstown, we meet hills covered with earth and loose pieces of the white sandstone, F. I. South of Seitz's limestone quarry, commences a chain of hills covered with diluvium and fragments of sandstone, on the top of one of which, that nearest the Hellerstown road, we find the conglomerate, which again occurs on the road leading S. W. to Coopersburg. A block of it was also noticed near the junction of the same road, and that leading to Allentown. The hill immediately south of the Hosacock creek, on the road from Shimersville to the corner of Upper Milford, consists of the conglomerate, which is here rather an incoherent rock, composed principally of primary pebbles.

The only remaining patches of conglomerate within the district, are in the southern part of Berks. A small exposure of it occurs on the Manatawny creek, below Rhoad's mill. Its beds here dip at an angle of about 10°. It next appears on the south side of Limekiln creek, Exeter township. The last and longest belt commences near the Perkiomen turnpike, and runs to the Schuylkill, rounding the southern point of the Neversink mountain, and crossing the Schuylkill, to terminate about two miles below the borough of Reading.

CHAPTER II.

Geology of a portion of the country lying N. W. of the Allegheny mountain, embracing part of Centre, most of Clearfield and Cambria, nearly the whole of Somerset, and parts of Indiana, Westmoreland and Fayette counties.

Beginning our description of the country, immediately N. W. of the Allegheny mountain, on the waters of Beech creek, in Centre county, where the operations of the previous year ended, we shall pursue the order heretofore adopted in these reports, by treating of the south-eastern belts and basins first, and tracing the formations in each of these, from the N. E. towards the S. W. The region now before us, like its extension towards the N. E., in Lycoming and Tioga, described somewhat in detail in my last annual report, consists of a series of long, narrow and parallel basins, separated by intervening table-lands and ridges, of different geological formation from the basins. All the strata within this wide tract of country, belong to only the five uppermost of our great Appalachian or lower secondary formations, from the red sandstone, F. IX., to the coal measures, F. XIII., inclusive. The whole having been lifted by a subterranean elevating movement, exerted along particular lines, the uppermost strata have been swept away by the accompanying floods, leaving the surface throughout these higher tracts, to consist of those formations which immediately underlie the coal, especially of the hard sandstones and conglomerates, composing F. X. and F. XII. The valleys between the ridges, being on the other hand, less exposed to the denuding violence of the currents, still retain the easily destructible uppermost formation, the coal measures, which the other districts have lost.

We shall enter, in the first place, upon a detailed account of the first or south-eastern basin, or that which follows the western side of the Allegheny mountain, through Clinton, Centre and Cambria. This basin was described in my last report, from the Loyalsock, on the N. E., to the head of the Tangascootac, where the examinations of 1839 terminated. Resuming the description at the latter point, where the waters of Beech creek interlock with those of Tangascootac, we find the coal measures, hitherto forming a narrow strip along the south branch of the Tangascootac, gradually widening and receding from the mountain, as we trace them towards the S. W. The main stream of Beech creek, flowing close to the north-west foot of the mountain, we meet with none of the productive coal measures immediately on either side, its hills consisting of the sandstones of F. XII., and only the great lower bed of sandstone of the coal series. Between these two unproductive strata, no coal nor any indications of it could be detected. The nearest outcrop of a coal seam, is one which occurs a little north of the turnpike, and which is about four miles N. W. of the eastern summit of the mountain. This coal lies between sixty and seventy feet above the top of the silicious conglomerate, which here forms F. XII. The bed is 4 feet 4 inches thick, and contains a thin seam of slate. The coal, which is good, has been mined to some extent. It may be traced over a considerable range of country, by a bench or little terrace, which marks its outcrop near the summits of the hills. This indentation, near the tops of the hills, rising and becoming indistinct at the edge of the coal basin, disappears entirely about a mile and a half E. N. E. of Snowshoe. Three quarters of a mile N. of the spot where the coal is opened, we discern the smut, which marks the outcrop of the coal at "Lucas's Sugar Camp," where an excavation, formerly made, has now caved in, hiding the thickness of the coal. The report throughout the neighborhood is, that the bed here is 9 feet thick, and contains a band of clay three inches thick.

At the principal mine, which is on the turnpike, the coal bed is 6 feet thick, including a layer of cannel coal, 6 inches thick, which runs through the middle. The roof here, is also of slaty cannel coal, the body of the seam being, however, a beautifully brilliant and pure glance coal. It has a very sensible dip, inclining at an angle of several degrees, and to an unusual quarter, the N. E. and N. Coal in considerable quantity is transported from this mine to the country E. of the Allegheny mountain, during the winter months.

Overlying the seam just described, we find, where the hills are high enough, another bench or indentation, marking a coal seam, between twenty and thirty feet above the former. This coal appears to be thin and unpromising. Iron ore, though in small quantity, occurs in a bed of brown shale beneath the first or lower coal seam.

In the country extending many miles N. E. from Snowshoe, we find a range of "High lands" along the heads of the north-western branches of Beech creek, where the rocks next beneath the coal measures occupy the entire surface. These owe their elevation to the first anticlinal axis west of the Allegheny mountain. Like the rest of the high belts, between the coal basins, the surface of this region is rugged and stony, and ill adapted to tillage, while it is wholly worthless in mineral productions. The iron ore, appertaining to the red shale, F. XI., may be met with in its usual position, just below the sandstone of F. XII., but in a country so wild and destitute of coal, possesses little value. Indications of this ore appear in springs, depositing much bog ore in a more accessible region lying south of the turnpike. These occur between the two branches of the Moshannon, on the line separating the lands of Jacob Gratz, Esq., from those of the Portland Lumber Company, and again about a mile up the Big Moshannon, south of the point where the "Indian Path" crosses it.

In this neighborhood, the first coal which shows itself as we pass westward from the ridge of the Allegheny, occurs in the hills along the Indian path, near the mouth of the Little Moshannon. Two benches, marking two different coal seams, were traced along these hills. Descending to the Little Moshannon, we meet the "Brown Rock," or the sandstone below the lowest coal seam, finely exposed in the steep hill slopes, and just beneath this, the coarser beds of F. XII. The strata here dip 4° to the N. E. Indications of two good coal beds were met with, where the "Indian path" diverges from the Karthaus road.

From a little above the mouth of the Little Moshannon, nearly to Philipsburg, no coal was discovered along the S. E. side of the main or Big Moshannon. But at Philipsburg and southward, up Cold stream, coal occurs abundantly to within a mile and a half of the eastern crest of the mountain. Six miles N. E. of Philipsburg, there are indications of the ore of the red shale, F. XI., on the turnpike near the Moshannon. It lies under the coarse sandstone F. XII. which here constitutes the principal part of the hills. This ore is deserving of further investigation. Below this, on the creek, springs depositing bog ore, are frequent. The red shale, F. XI., forms the bottom of the valley of the Little Moshannon, near its mouth.

Philipsburg.

The principal mines now wrought in the valuable mineral district around Philipsburg, are on the north side of the Moshannon, opposite the village. The following section, compiled from measurements obtained at this spot, will show the number and relative position of the several beds:

Section, Descending.

Upper strata of moderate thickness, not determined.				
Coal,	4	feet.		
Fire clay,	2	"		
Calcareous slate,		"	8	inches.
Bright blue compact shale, (indurated clay,)	1	"	2	"
Ferruginous shale,	2	"		
Blue limestone, ferruginous,	5	"		
Sandstone and slate,	19	"		
Coal, of excellent quality,	4	"	4	"
Fire clay,	2	"		
Ferruginous limestone, passing into iron ore,	2	"		
Sandstone,	16	"		
Coal, in the bed of the creek,	1	"	8	"

The middle coal seam, represented in the above section, the only one now wrought, is mined to a considerable extent. It is four feet four inches thick, is of sound texture, and excellent quality throughout, and will afford solid blocks of coal the whole thickness of the bed, and as much as eight feet in length. The upper coal bed of the section is stated to have been opened formerly, and found four feet thick. From the low position of these beds, they must range through a wide extent of country. A shaft, sunk by us two miles west of the above locality, brought to light a bed of coal, which is either the uppermost of the section or a still higher seam. The strata passed through, will be seen from the following *section:*

Olive shale,	10 feet.
Coal,	4 "
Fire clay, gritty,	2 "
Decomposed, ferruginous, calcareous sandstone,	3 " 6 inches.
Nodular limestone, in shale.	

Throughout the country immediately north of Philipsburg, a brown iron ore is found, loose in the fields; it is possibly derived from the ferruginous stratum mentioned in the section. The appearances at several localities are such as should induce a more thorough examination by the proprietors. One spot is at Runk's, on the turnpike, three miles N. W. of Philipsburg, and another two miles north of the village. Examinations were once made at the latter place for hematitic ore, with the anticipation that it would prove like that of the limestone valleys east of the mountain; but the operations were abandoned. A third locality is on Geerhart's farm, near the creek, a mile and a half S. W. of Philipsburg. Here loose pieces of limestone occur, associated with the ore. It is probable that all these exposures belong to the same part of the formation.

Coal occurs in abundance on the farm of John Goss, about five miles W. S. W. from Philipsburg, and six miles N. W. of the summit of the mountain. This is on the N. W. side of the Moshannon, and a mile and a half S. E. of a high ridge, supposed to contain the first anticlinal axis, here much flattened, N. W. of the mountain.—The following section exhibits the position of the coal at this place:

Section descending.

Coarse brown sandstone, thinly bedded.	
Black slate—roof of the coal.	
Coal, too near the surface to be worked,	7 feet.
Undetermined strata,	20 "
Coal,	2 "
Undetermined strata,	15 "
Coal, separated into two beds, by a seam of interposed slate, 8 inches thick, 2 feet from the bottom,	8 " 10 inches.
Limestone, thickness not ascertained.	
Kidney ore, quantity unknown.	

The lowest coal seam being separated into two beds, only the uppermost, which is 6 feet thick, is worked. It affords an excellent sound coal, free from sulphur and slate. This seam exhibits that tendency to a columnar structure which is so common a feature in the coal of all the basins immediately contiguous to the Allegheny mountain. From its low position, in reference to the other strata, it ranges over a considerable extent of country, though all attempts to identify it have hitherto failed. The uppermost coal seam, in the section, occurs so near the top of the hill, as to be too soft and dirty to work; from the same cause it does not spread over much extent of surface. Coal occurs at two or three other places in this neighborhood, showing a thickness of about 4 feet; but, whether these localities belong all of them to one seam or to two, could not be ascertained. From Philipsburg, S. W., the centre of the basin coincides very nearly with the general course of the Moshannon creek, the strata on each side, dipping gently towards the stream. The coal beds, along the S. E. side of the basin, here, near the top of the mountain, do not correspond with those above described. They have been developed in the dividing ridge, between Coal stream and Trout run, called "coal hill." The lowest bed, at this place, has its outcrop about a mile and a half N. W. of the summit. It was here discovered and opened by us, and found to contain 5½ feet of coal, resting on more than 6 feet of excellent fire clay. The fire clay lies within 6 or 8 feet of the conglomeritic rock, F. XII., the "Brown Rock" being here absent. About fifty feet above this coal bed, occurs another, 9 feet thick, divided into two seams, by 10 inches of interposed slate, two feet from the bottom. The upper division, 6 feet thick, alone is worked. This coal is of sounder texture than most of that near the mountain, admitting of being mined in large square blocks. It is free from sulphuret of iron. This same bed has been opened, two miles nearer to Philipsburg; it and the lowest seam have been estimated to occupy as much as four square miles of surface, in the country between Trout run and Cold stream. The thick upper bed, here mentioned, lies at a level 250 feet below that of the summit of the mountain, at "Emigh's Gap," which is about four miles distant. Should the proposed railroad over the mountain take the route of this gap, or that of Logan's Narrows, fourteen miles distant, the coal here spoken of, would become of great importance. In Coal hill, we have indications in the benches on the surface, of at least three other coal seams—the smut only of two of which being penetrated; one proved to be 18 inches thick, and the other 4 inches; no attempt was made to open the uppermost. These benches, or indentations on the sides of the hills, when distinctly marked, are unerring indications of the presence of beds of coal. The dip is about 5° N. W.

Examinations were made in this vicinity, in search of the iron ore of the red shale F. XI., some old openings giving promise that the ore might here be found. The excavations, commenced by ourselves, were prosecuted with much spirit by Mr. Philips, who has shewn great zeal in developing the mineral resources of the rich neighborhood before us. Ore has been found in several spots accompanying the white and red clay, or decomposed shale, immediately below the grits of F. XII., but the coming on of winter has prevented the proprietor from determining the thickness of the deposite and quality of the ore. A rather thick ferruginuous bed does occur here, but no specimens have yet come to hand, enabling us to pronounce upon its value. Should this ore of F. XI. prove productive, the place would unite many advantages for the establishment of iron works, lying near the fertile valleys east of the mountain, and possessing an abundant supply of coal, excellent fire clay and sandstone, a sufficiency of limestone and excellent timber, both oak and pine, and an ample water power on Cold stream. The country, here abounds in excellent white pine which is always best towards the heads of the streams. Cold stream now drives a large saw mill and a forge. During the winter months, coal in considerable amount is hauled by the route of Miller's gap, into the valleys S. E. of the mountain, where it is sold at the rate of fifteen cents per bushel.

On the eastern fork of the west branch of Muddy run, on the county line dividing Clearfield from Cambria, there occurs a large deposite of rich bog ore, (see analysis,) covering about two acres, and further down the run, for a mile and a half, the springs in many places precipitate the same ore in the form of a red ochre. This material is probably derived from the red shale, F. XI., the surface on the western flank of the mountain sloping rapidly to this point. A sandstone corresponding in character to F. XII., shows itself in the steep slope above the flats of the stream; it is probably between 30 and 35 feet thick. Four other benches appear higher up, the second of these, ascending, is watered by a spring, and the third and fourth exhibit signs of coal and fire clay. It is said that springs depositing bog ore occur in many places along the summit of the mountain, in a position answering to that of F. XI., and in some places in sight of the furnaces and forges in the valleys below.

Mount Pleasant.

In this neighborhood we meet with numerous indications of coal and limestone, though the inhabitants have rarely been at the trouble to develope either. Only one coal bed, 2 feet thick, has hitherto been opened, though the benches in the hills, and the smut exposed in the fields, imply the existence of three other seams.

Along *Clearfield creek*, near Blain's run and Turner's run, coal, fire clay and limestone are abundant, and judging from the evidences of iron ore, enough of this mineral may possibly be found to make this a valuable locality. A little up Blain's run, there is a bed of good coal, 5 feet thick, near the level of the stream, and under it fourteen feet of fire clay, a part of which is well adapted for making stone ware, and the rest fire brick. A manufactory of the latter, owned by Mr. Campbell, has been established here, which yields sometimes fifteen hundred bricks per day. In making the fire bricks, the clay is ground *dry* in a wooden trough by a heavy stone roller. The bricks are sold *on the spot* for $20 per thousand, while some are carried in rafts down the creek and the Susquehanna, and some hauled east of the mountain and elsewhere. Different varieties of good stone ware have also been manufactured to some extent, other seams of coal and indications of iron ore occur higher up in the same hill above the coal already spoken of.

Further down Clearfield creek, a little above Porter's run, Mr. Wright owns three beds of coal, two of which are each 2 feet thick, the other 3 feet. He has also a bed of limestone 4 feet thick. Good kidney ore, sometimes in one, sometimes in three bands, may be traced along the edge of the creek for several miles. The nodules are occasionally very large, but it is feared the quantity is insufficient to warrant mining. In this neighborhood other beds of limestone were met with.

Between Mt. Pleasant and the Portage Railroad, the nature of the country is such as to render a minute exploration extremely difficult, so generally are the strata concealed at their outcrop by the soil, and so few have been the developments undertaken by the inhabitants. The prevailing formation is that of the coal measures, beds of coal and limestone being occasionally met with, but no seams of much importance have hitherto been discovered. The unpromising nature of the country prevented our devoting that large amount of time to it, without which, it was soon ascertained, nothing effectual could be accomplished towards determining its mineral resources.

The Second or West Branch Coal basin.

Describing the several coal fields in their order towards the N. W., the next which claims our attention is the second, or West Branch basin. Tracing it from the N. E., to the S. W. as a continuous trough of coal measures, it reaches the river Susquehanna near the mouth of Young Woman's creek, which it crosses, passing afterwards Kettle creek, near its mouth. But in this part of the country, immediately north of the river, the basin is very shallow; only a thin remnant of the coal measures capping the very highest hills. West of the mouth of Kettle creek, coal was once opened, three miles from the river up Cook's run, where, it is stated, the coal was 4 feet 2 inches thick, parted in the middle by 2 inches of slate. At a somewhat lower position in the hill, between F. XII. and the "brown rock," a bench occurs which may denote another coal, though none is at present known to exist here. A bed, corresponding to that above mentioned, is said to have been once opened on the south side of the river, opposite the mouth of Cook's run. A little S. E. of the last locality, the land rises by the cropping out of the lower formations that fold gently over the anticlinal axis separating the first and second basins. At the mouth of the Sinnemahoning, the red and grey flaggy rocks reach a height of fully one hundred and fifty feet above the water, but only emerge above the river flats at the mouth of Cook's run. The hills around the head of Cook's run are very high, but consist of formations which forbid the hope of finding coal. The iron ore of F. XI., may perhaps underlie the conglomerate on the hills, though the probability is slender of its being of sufficient thickness to be profitable.

From a point several miles below Karthause, the coal measures in the river hills are quite productive, embracing several bands of iron ore, limestone, and some excellent coal seams; and near Three runs, we have besides, promising indications of the ore peculiar to the upper beds of F. XI. The coal basin deepening gradually as we ascend the river, the large upper bed at Karthause does not enter the hills, until we pass above the neighborhood of Three runs. At the latter locality occurs a bed of coal, 3 feet 2 inches thick, which has been opened, associated with a layer of *limestone* and one of *fire* *clay*. Openings were once made into a coal bed and band of iron ore on the south side of the river, at a point high up in the hills; but the success of the exploration is unknown. Tracing the coal rocks back from the river for two or three miles in this direction, we find them gradually rising until they appear, finally, only in the highest knobs, beyond which they are succeeded by the coarse beds of F. XII., expanded over the elevated tract designated "Highlands" on the State map.

At Karthause, the coarse sandstones and pebbly rocks of the upper part of F. XII. occupy the bed of the Susquehanna. The strata here dip about 5° towards the N. W., and preclude therefore any hope of finding the *iron ore* associated with the upper layers of F. XI. At Three runs, lower down the river, the gentle rising of the strata may bring this part of the series into view, as already mentioned. The ore was here sought for just previous to the abandonment of the enterprise at Karthause. A still more suitable spot will be on the S. E. side of the river, directly opposite the Karthause mines, on a small run divided from the river by two knolls. Here the conglomerate, F. XII., forms a perpendicular wall, twenty-five feet high, the stratum dipping at an angle of 5°. The iron ore of F. XI. should be searched for immediately at the base of this rock. Mr. John James, the chief miner of the Karthause furnace, when it was in operation, compiled with considerable care, a general section of the strata from the water level to the summits of the hills near the furnace. This we shall append here, with a few trivial additions of our own:

Section of the Strata at Karthause.

Summit of the hill, five hundred and sixty-five feet above the river.

Slaty sandstone, said to contain a coal bed 2 feet thick,	79 feet.	
Black slate,	1 "	
Coal, elevation 479 feet,	6 "	
Fire clay, of inferior quality,	2 "	6 inches.
Brown sandstone,	45 "	
Coal,		10 "
Hard fire clay,	2 "	
Limestone, siliceous,	3 "	6 "
Shale, with poor iron ore,	1 "	
Brown sandstone,	25 "	
Coal,	3 "	

Slate,	1 feet	6 inches.
Grey sandstone,	37 "	
Coal,	3 "	2 "
Shale, containing about 26 inches of good kidney formed iron ore, elevation 345 feet,	11 "	
Coal,	1 "	
Brown sandstone and slate,	21 "	
Coal, including 3 inches of slate 1 foot from the top,	3 "	9 "
Fire clay,	2 "	6 "
Brown sandstone,	35 "	
Coal,	1 "	6 "
Fire clay, ferruginous,	3 "	
Shale, containing about 25 inches of good iron ore, called the "red ore"—elevation 268,	11 "	9 "
Shales and slates, with a little unimportant iron ore,	22 "	
Coal,	1 "	
Sandstone, the "brown rock."		
Thin coal seam,		
Conglomerate and coarse sandstone of F. XII., down to the river, amounting with the brown rock, to	240 "	

There are in all ten coal seams of greater or less size in this part of the basin. The thick bed near the top is the only one hitherto mined. Lying near the summits of the hills, it does not, in the immediate vicinity of the furnace, occupy more than about forty-three acres, though it enters a few small knobs to the north and to the S. W., where the covering strata are thin. This bed is altogether 6 feet thick, but this includes 1 foot of inferior coal, near the top, which is not mined; the remainder of the seam consists of very excellent coal, adapted to making a superior coke. Lower down in the measures, occur two important beds of iron ore. One of these, at an elevation of three hundred and forty-five feet above the river, is estimated to contain in all 2 feet of good blue kidney ore in 11 feet of shale. The other stratum lies at an elevation of two hundred and sixty-eight feet. It also exhibits about 2 feet of good kidney ore, in a stratum of shale less than 12 feet thick. This band is locally called the "red ore," and is of a different variety from that above it; they are both of excellent quality.

The limestone of this neighborhood, is for the most part inferior; only one bed of it, 3½ feet thick, occurs in the series. Besides the thick upper coal, there are three others of a size suitable for mining, one of which, 3½ feet thick, and the two others, each 3 feet, but none of these supply as pure a coal as the main seam.

Nine miles above this, on the river, the "red ore" has been found, and is stated to be thicker than at Karthause. Three miles higher up, there occurs a bed of coal near the summits of the highest hills, which measures 4 feet 4 inches in thickness; this, there is some reason to suppose, is part of the main Karthause seam. Between the two localities mentioned, appears a bed of limestone. In this neighborhood the sandstone rocks of F. XII., occupy a position near the flats of the river. The coal measures spread but a moderate distance from the river on either side, the underlying conglomerate of F. XII., rising out and capping the hills every where from three to five miles off from the river.

Much difficulty was experienced in the district around the town of Clearfield, in identifying the coal seams of neighboring localities, and after close investigation, aided by frequent diggings, the stratification remains quite obscure. We are in doubt to what causes to attribute the intricacies of the region; whether to local displacements of the strata, sudden variations in their thickness, or an insufficient collection of facts. Our descriptions will therefore be necessarily restricted to a mere account of the position, and economical importance of the leading beds at several localities, leaving for a future day the task of generalizing our results.

The largest and best coal seam, in this division of the basin, is that on the property of Mr. Thomas Reed, near the bridge over the Susquehanna, two miles from Curwinsville. It lies between eighty and ninety feet above the river, dipping at a considerable angle to the N. W. The coal bed is here 3 feet 6 inches thick. We have been told, that one hundred thousand bushels of this coal have descended the Susquehanna to Harrisburg. It forms an excellent fuel, as it contains but little sulphur. Like most of the coal beds of the south-eastern bituminous basins, it affects a species of columnar structure, being traversed by innumerable vertical fissures, which render it somewhat friable. For its composition, consult the chapter of analyses.

Attempts have been made to trace the above coal seam into the neighboring hills, where however, no bed corresponding to it in thickness and quality has been discovered. Several other seams exist in the accompanying strata, but none of them possess economical value. Underneath the coal seam, above described, is a bed of *limestone*.

On the north side of the river, three quarters of a mile above the town of Clearfield, occurs a stratum of fire clay, of good quality, and 8 feet thick. Its position is a few feet above the river bank.—*Oolitic iron ore*, seemingly of good quality, abounds in the upper part of the fire clay, 2 feet of which appears to contain about 1 foot of ore. A layer of similar oolitic ore, supposed to be the same, exists on Clearfield creek, near the water side, at the point of the long bend, amounting to nearly 2 feet of ore balls in close contact. It it is here associated with fire clay, and a few thin bands of coal and coal slate, containing more ore. In the steep hill above this bed, lie two layers of *limestone;* the lowest of these is a pure rock, 6 feet thick. Several beds of coal are also known to exist here; but, as in the former locality, they are all of unimportant thickness. The proper place in the strata, for Reed's coal, is above the thick limestone, where there is a space of fifteen feet of materials not developed. The above mentioned bed of ore, lying adjacent to the river, is easily accessible.

At the town of Clearfield, a seam of good coal is wrought to some extent. It lies between forty and fifty feet above a stratum of sandstone that occupies the bed of the river. It measures 2 feet 10 inches in thickness. The outcrop of another bed shows itself near the top of the hill, a mile south of the town; this seam has no where been accurately developed. The first spoken of, is conceived to be the same with Owen's bed, two miles up Clearfield creek, where the coal is 3 feet thick, and of excellent quality. Over it are the indications of three other seams. It has been mined in another place, three miles up the creek, where its thickness however only amounts to 20 inches. Though several other coal beds occur here, this lower one is the thickest thus far discovered.

Besides the band of *iron ore* already noticed, several varieties of this mineral occur along Clearfield creek. A rather peculiar, rough looking ore, in large masses, some of them more than one hundred pounds in weight, strew the surface of a tract of land belonging to Perley, Blake and Crane, of Boston, lying a mile south of the old turnpike. The mineral is heavy, but evidently not very rich in iron. For its composition, consult the analyses. A somewhat similar ore, possibly a part of the same bed, is to be seen, on the east side of the creek, at Beer's, where, though the surface indications are encouraging, the quantity of the ore has not been proved. A peculiar compact shale or indurated slate clay, of a bright blue color, accompanies these ores, and is likewise found in association with another variety, three miles up Little Clearfield creek. Here the shale, which is 12 feet thick, is less blue; scattered through it, are small balls of ore. Beneath this is a considerable quantity of a coarse ore, in very elongated, somewhat cylindrical masses, like bars of pig metal; it does not appear to be rich. On the old turnpike, near the tenth mile stone west of Philipsburg, appear two seams of good kidney ore, requiring further digging, in order to determine their value. On the new turnpike, near Roaring run, a spring issues from directly beneath loose masses of conglomerate, and deposites the red oxide of iron in a large bog. This spring forms a stream which propels Bloom's saw mill. It was impossible to decide whether the conglomerate belongs to F. XII. or not, though the ore spring renders it probable, that we have here the contact of that formation with F. XI., indications being sufficient to justify a more minute examination by the owner, for the hard ore at the top of the red shale.

Between Little Clearfield creek and Mount Pleasant, the whole country consists of coal measures, none of the lower formations shewing themselves in the position of the anticlinal axis, which elsewhere separates the first and second basins. The chief feature, indicating the existence of an anticlinal axis between Philipsburg and Clearfield, is a high dividing ridge, where, however, none of the lower rocks make their appearance. The obscurity in the outcrop of the strata along Little Clearfield creek, prevented our ascertaining clearly the stratification in that neighborhood, to determine which, would have required more time than we were possessed of. This valley shows several good beds of limestone, and some coal. At Mr. Wright's, above Porter's run, there are three coal seams, two of which measure each 2 feet, and the other three feet thick. There is besides, a bed of limestone, 4 feet thick; one, in some places three layers of good kidney ore, lying in shale, can be traced along the banks of the creek for several miles; the lumps are occasionally very large, but the whole quantity hardly sufficient to pay for mining.

The country occupying the prolongation of this basin, from Curwinsville to the Conemaugh, was not explored by us, its examination being unavoidably postponed to another season.

The Third or Bennett's branch basin.

Between the north-western margin of the Karthause basin, and a third and parallel trough of coal measures on Bennett's branch, we pass a wide tract of elevated barren country, consisting of the coarse rocks of F. XII., which are here lifted to the surface by a broad and flat anticlinal axis. This axis of elevation, dividing the two coal fields, crosses the east branch of Sinnemahoning a few miles above its mouth; then, curving gently southward, it passes the Sinnemahoning at the mouth of the Driftwood branch, to range in a W. S. W. direction, through the high land, dividing the waters of Clearfield creek from those of Bennett's branch. The belt of country immediately along this line, presents few mineral features of importance. The sandstone and conglomerate rocks of F. XII. cap the highest hills. Indications of iron ore occur in a few bog ore springs, visible near the Sinnemahoning, but the great height, and steepness of the hills, at the very summits of which it must lie, would render the ore, even if abundant, difficult of access.

The synclinal axis, marking the middle of the third coal basin, crosses the east branch of the Sinnemahoning, about ten miles above its mouth, and the Driftwood branch at the same distance from its outlet, following the course of the stream. On the west side of the Driftwood branch, one bed of coal has been discovered and opened near the level of the highest lands. A body of productive coal measures may possibly exist between this and Bennett's branch, though from the obvious shallowness of the basin here, the existence of such appears improbable. The country is excessively wild and rugged. The apparent extension of the coal measures for five or six miles N. W. of Bennett's branch, up Hick's run and Trout run, is a matter which claims some attention on the part of the proprietors of lands in this quarter.

At *Caledonia*, on Bennett's branch, the basin becomes productive, the stratification embracing coal, iron ore and limestone. This place is on the main stream, about six miles above the mouth of Trout run. The hills on either side attain an elevation of about five hundred and fifty feet, which they preserve for three or four miles back from the stream. On the S. E. margin of the basin, the rough rocks of F. XII. are visible on the Karthause road, four miles south of Bennett's branch, dipping gently to the N. W., and this dip continues to the north side of the stream, the strata of F. X., two miles above Trout run, showing an inclination of nearly 5° in that direction. This northern dip, however, must soon change, for on Wolf run, between six and seven miles N. W. of Bennett's branch, the coarse rocks of F. XII. again rise in the contrary direction, and cap the higher hills that bound the basin on the N. W.

Although F. XII. at Caledonia, (Warner's,) lies but little above the flats which border the stream, yet four miles lower down the valley, in a N. E. direction, the subjacent rocks of F. X. appear at least two hundred feet above the level of the water. This is due chiefly to the gradual ascent of the basin in that direction, and but slightly to the fall of the stream; hence the probability of finding but a very limited amount of coal measures still further to the N. E., on Trout run and Hick's run. In the grey slaty sandstones of F. X., there occurs a bed of indifferent sandy limestone, about 4 feet thick. This contains many fossil shells and other marine remains, including those of one or two species of fishes. Associated with this limestone, we find many little yellowish balls of excellent iron ore. Between formations X. and XII., we meet with indications of the bed of iron ore, everywhere so prevalent in F. XI., which, as a separate formation, seems itself to have thinned out. Up a little run, to be seen a mile and a half below Caledonia, we find a deposite of the soft bog ore derived, as usual, from springs flowing out of this part of the strata. We discovered a fine natural exposure of the bed of hard ore, before unknown, about a mile and a half above Caledonia, on the edge of Bennett's branch. At the latter place, the current has cut away the loose rock and covering soil, leaving the ore in view under the overhanging sandstone of F. XII., the bottom of which is within eight feet of the water. Immediately beneath the sandstone lies 1 foot of black shale and, under this, 3 feet of brown shale containing scattered nodules of the ore, underlaid by a solid bed of the ore, forming, with a very little shale, a bed between 3 and 4 feet thick. This overlies a band of fire clay. This ore somewhat resembles that found at Astonville, and described in my fourth annual report. A recent slide of earth and loose rock, somewhat concealing the layer, prevented our ascertaining its thickness with perfect precision. This promising exposure is on a tract of land stated to belong to a lumber company of Portland.

Formation XII., the exact thickness of which was not satisfactorily determined, varies from a moderately coarse sandstone to a rough quartzoze conglomerate in which the pebbles are occasionally larger than a turkey's egg. Large masses lie loosely scattered in great abundance. They present blocks of all sizes and every degree of relative fineness of texture, and admit of being easily split into fragments adapted to almost any building purpose. The whole stratum is probably about 100 feet thick, its lower edge, at Warner's, occurring about forty feet above the level of the stream. Above the top of F. XII., the strata, which should contain coal, offer no exposures throughout a thickness of many feet. Near the head of a small stream, four miles below Caledonia, the upper edge of the sandstone is caught, lying about three hundred feet above the flats; and very near this is a bed of compact yellowish shale, 4 feet thick, somewhat resembling externally, a limestone. In no other place was this bed, or any other, visible near the top of F. XII. The "brown rock," so usually met with in this position, was not recognized. The first stratum met with in the ascending order, was a dark blue shale, which occurs about forty feet above F. XII. We had some reason to suppose that the interval contains a bed of coal. From the level of this shale upward, a tolerably minute section of the strata was procured by the aid of the pick and shovel, and the results contrasted with observations made in adjacent ravines and gorges. Some of the beds, thus developed, were found exposed on Warner's run, and other thin layers detected on Mead's run, lying a mile to the east. From these various data, the following somewhat detailed section of the rocks has been compiled. The more complete portion of the section terminates at the great bed of sandstone, 100 feet thick; but we have introduced several of the overlying beds in the order in which they were observed, ascending the highlands north of the sources of the above streams.

Section of the coal measures on Bennet's branch near Warner's:

White sandstone, coarse, approaching a conglomerate,	50 feet.	
Coal, indicated by a bench,		
Yellowish sandstone; there is a limestone either above or below this bed,	40? "	
Brown shale, thickness unknown,		
Coal, opened at Brockaway's, on the turnpike,	2 "	6 inches.
Fire clay,		6 "
Sandstone, grey, slaty, with some interstratified shale,	100 "	

Black and dark shales, containing kidney ore,	20 feet.	
Coal; the upper 6 inches cannel coal,	3 “	
Fire clay, dark colored,	1 “	6 inches.
Fire clay, blue, of good quality, the upper part containing many balls of iron ore,	8 “	
Ore stratum, with fire clay, 3 feet 6 inches, comprising oolitic iron ore,		3 “
Blue fire clay,		12 “
Oolitic iron ore,		6 “
Blue fire clay,		6 “
Oolitic iron ore,		3 “
Blue fire clay,		12 “
Compact shale, blue and yellow, resembling externally, a limestone, its upper part containing oolitic iron ore,	8 “	
Olive shale, containing shelly ore,	8 “	
Blue sandstone,	1 “	
Shale, with iron ore; lower part of the stratum sandstone; the ore is abundant,	45 “	
Olive shale,	15 “	
Coal,	1 “	6 “
Blue slaty sandstone,	5 “	

Limestone stratum with fire clay, 6 feet thick, comprising:

Limestone,		10 inches.
Fire clay,		12 “
Limestone,	3 feet.	
Fire clay,	1 “	
Dark colored shale, the lower 4 feet, embracing ore,	10 “	
Olive shale,	2 “	
Coal,—inferior, being slaty cannel coal,	1 “	6 “
Black shale,	3 “	
Coal, of good quality,	5 “	
Black shale,	2 “	
Sandstone,	10 “	
Black shale,	4 “	
Sandstone and olive shale, with kidney ore,	30 “	
Limestone,	4 “	
Sandstone,	10 “	
Dark bluish shale,	6 “	

On several of the adjoining runs, the iron ore has been dislodged from its shale in great abundance, and the indications are such that we believe it might be profitably mined in several drifts on the same stream. On the Clearfield road, one mile from Caledonia, there is an exposure of iron ore on the road side, but the exact place in the series, occupied by this section, has not yet been ascertained. It has been thought to be the same band as the "red ore" of Karthause. Its position is not far above the upper edges of the conglomerate, F. XII. It consists of balls of heavy ore, embedded in shale, one fourth of the lower 3½ feet of which consists of the ore. The excavation, made to expose it, evidently did not bring the whole of it to light.

The five feet bed of coal was discovered and opened by us where the above section was made, but we afterwards ascertained that it had been uncovered on other streams. This seam, consisting of sound coal without any slate, measures in one place 5 feet 2 inches in thickness. The lower limestone is blue, but it is not compact or close grained. The upper limestone, probably the best of the two, is less blue, and of a finer texture. The blue and yellow compact shale, somewhat resembling a limestone, is a singular layer; it is often variegated, resembling occasionally a breccia, and is susceptible of a good polish. Iron ore occurs abundantly in the shales above the second limestone, but in consequence of the difficulty we encountered in opening these beds and ascertaining the exact quantity of ore, we cannot venture to say more than that the indications are very promising. The quantity of the oolitic ore is considerable. The fire clay on Mead's run is a rather heavy bed, and resembles precisely that worked at Farrandsville. The 3 feet bed of coal, containing in its upper part 6 inches of cannel coal, supplies a fuel much esteemed by the blacksmiths; besides occurring at this locality, it is found four miles north of Bennett's branch, at a spot, a mile east of the turnpike. In the upper part of the coal measures, we met with one or more beds of fossiliferous limestone.

The facilities for mining the iron ore, coal and limestone in this neighborhood, are certainly considerable, and these minerals lie, all of them, convenient to an ample water power, which might be derived either from Bennett's branch or Laurel run, affording if necessary, a fall of fifty feet, and water enough for extensive iron works. The iron might be conveyed to market by the Susquehanna, on rafts, the timber of which will pay, it is thought, all the expenses of the transportation. But these could only run during the spring, and occasionally in the summer, in times of freshet. During the winter, it is said, there is good sledding along the river on the ice. To reach a western market, it would be requisite to haul the metal about twenty miles, upon a pretty good road, to the Clarion river, whence it could be sent in rafts and arks from Ridgeway to Pittsburg. The neighboring country is capable of maintaining ultimately a considerable population.

The basin, of which we have here been treating, extends to the S. W. up Bennett's branch. It was found to be rich in coal and limestone for ten or twelve miles above Caledonia. But the natural exposures of the strata near the sources of the streams are very few, and we found it almost impossible, with the limited time we had at our command, to procure a good idea of the stratification. The basin, both on the N. W. and S. E. sides, is bounded by high barren table lands, in belts about five miles wide, capped by F. XII. The ridge of high lands on the N. W. is called Elk mountain. A few of the knobs on the flanks of these broad ridges probably contain one or more of the lower coal seams. The intervening valleys of denudation are fertile and sparsely populated.

Want of time did not permit us to complete the exploration of this third basin in its prolongation south-westward. Merging in that direction into the general basin of the western counties, its limits and stratification will be more clearly defined, when the opportunities of another season enable us to unite and identify the minuter features of the geology, west of Chesnut ridge and the Elk mountain. Some time was spent in the exploration of the tract along the Conemaugh, immediately west of Chesnut ridge, presumed to be a portion of the present coal basin; but the results of this examination belong more properly to a description of the great, westernmost basin as a whole, for which we are not yet fully prepared. At present, therefore, I shall content myself with a brief statement of a few particulars concerning some of the more valuable deposites bordering the Conemaugh.

About two miles east of Blairsville, at Christopher Hill's, on the canal, we discovered the iron ore of F. XI. It proved to be about 1 foot 6 inches thick, and to consist of irregular balls in close contact. The indications are, that the mass of ore, in from the crop, is more solid. The limestone, characteristic of F. XI., is here seen *immediately* under the ore. Only about two feet of it is exposed.

It contains a few fossils. The ore is exposed in several places ascending the river for a mile, nor does it disappear as we descend the river for an equal distance. It is indicated by a distinct terrace or bench, directly over which we behold the bottom bed of F. XII. This iron ore of the red shale was also found in the bank of the canal and river, opposite Jacob Hill's, three quarters of a mile below Christopher Hill's. A nearly solid band of it, 18 inches thick, is there exposed. It is a compact ore of rather heterogeneous structure; consult the analysis. Directly over it lies a layer of reddish shale, 3 feet thick, containing many nodules of ore, and upon this a bed of flaggy sandstone, 15 feet in thickness. This seems to be all that remains here of the usually massive stratum F. XII. Overlying the sandstone, at a small interval, is a bed of good limestone proved to be at least 26 inches thick. Not far above this, occurs a coal seam 4 feet in thickness. This has been opened at Lymangood's, near the foot of Chesnut ridge, where it closely adjoins F. XII., which is there in the form of a massive bed of coarse sandstone. About fifty feet above the upper edge of this formation, we find a large bed of coal, varying from 6 to 7 feet in thickness. This seam, which is here in high repute, rests on a layer of excellent fire clay, from 1 to 2 feet thick, underlying which, is a band of limestone 2 feet thick. Below the latter, lies 3 feet of shale, containing iron ore, probably to the extent of one-half of the whole mass. There is another bed of very good limestone, higher up in the hills, said to be between 3 and 4 feet thick. A little above the large coal seam occurs the lower edge of a great bed of sandstone, which has here a thickness of nearly 100 feet.

A mile east of Blairsville, the strata dip gently to the S. E., beyond which the inclination becomes imperceptible, and at Christopher Hill's they plainly dip to the N. W. The removal, or denudation of the upper strata in this neighborhood, has been just sufficient to render the ore bed in F. XI. accessible over a considerable space.

The Fourth or Toby's Creek basin.

Five miles N. W. of Bennett's branch, ranges the summit of the high ridge, designated on the map of the State as the Elk mountain. Its elevation above the stream is not far short of six hundred feet. The sandstone and conglomerate rocks, constituting F. XII., here reach the surface and form a rough and stony belt, nearly four miles wide. The rise of the strata on the N. W. side of the Bennett's branch basin is tolerably rapid. About half way across the broad anticlinal elevation of Boon's or Elk mountain, occurs a considerable exposure of red soil, derived either from the red shale and iron ore stratum of F. XI., or from the upper layers of F. IX., which latter formation, however, it can hardly be.

Crossing this broad ridge to the N. W., we enter the coal measures of the Toby's creek basin, the centre of which lies above five miles south of the turnpike, on a branch of Little Toby creek known as the Brandy Camp creek. The coal measures extend from the turnpike at the sources of Little Toby and Brandy Camp streams, to near the summit of Boon's or Elk mountain on the S. E. The conglomerate, F. XII., shows itself on the N. W. side of the ridge, a few rods from the turnpike, at a point about a mile west of the Jefferson county line, and presents a bold wall of rock more than twenty feet high. But a small part of this stratum is conglomeritic, the chief portion being a coarse yellowish sandstone, marked with ferruginous streaks. At the upper edge of the stratum is a layer of compact, white, siliceous sandstone. The stratum ranges north from this locality, which is near the source of the south branch of the Elk creek, across to the head of the north branch of the same stream, cropping out a little below the highest summits. The engineers who have surveyed this neighborhood, mention this rock as occuring at their summit, between the sources of Elk creek and West creek, which runs into the Driftwood. In its course to the S. W. the stratum twice crosses the Clarion, entering the tops of the hills at the mouth of Little Toby, and again a mile and a half above, from which line it spreads back four miles south-eastward, towards the Kersey settlement, on Brandy Camp creek, near the summit. On the Clarion river, one mile below the mouth of Little Toby creek, and about twenty rods above that of Bear creek, (Beaver creek on the map,) there occurs on the east side of the river a fine deposite of bog ore. The rocks of F. XII. descending, here occupy the middle third of the hill, and form a stratum at least 100 feet in thickness. Five or six springs, in a space of about thirty rods, issue along the lower edge of this rock, each of them depositing of the pulpy red oxide of iron along the slope leading down to the river. Probably twenty acres are covered with the deposite, the average depth of which may be given at seven feet. The coarse conglomeritic sandstone F. XII. is not exposed, but the more flaggy beds of F. X. show themselves at the base of the hills, where the contact of the two formations is clearly marked by an abrupt change of slope at the level of the springs. Huge blocks or masses of the overlying rock have detached themselves from the body of the stratum along the face of the hills. Though partly conglomeritic, the largest pebbles rarely exceed in size a hazel nut. The hills rise about one hundred feet higher than the upper edge of the conglomerate, and about half way in this interval, or about fifty feet below the summit, occurs an indentation or bench which may possibly imply the existence of a seam of coal here.

Several sections of the strata in different parts of the basin were obtained, some of them embracing an almost complete series of the rocks and included minerals. In these researches we ascertained the existence and position of two valuable beds of limestone, which we believe to be continuous over a considerable space of country, together with another middle band found to be destitute of fossils, and the continuity of which we consider doubtful. The sections are compiled from observations, made in one case on the east side of Brandy Camp creek, about five miles south of the turnpike; in another instance at a point nearly opposite, on the west side of the same stream; and in a third at Kyler's situated near the head of Little Toby. Some of the results included in the sections were procured near the head of Brandy Camp creek, at Mr. Thompson's, and on Limestone run, which enters Little Toby four miles below Jesse Kyler's. A large deposite of red bog ore occurs adjacent to the conglomerate and seems to be connected with filtration through the body either of this rock or of one of the ferruginous sandstones above it. Though no satisfactory exposures of F. XII. were here seen near the level of the ore, the stratum was detected in the bed of the stream, at a somewhat lower level, one mile lower down the Brandy Camp, and twenty rods beyond was seen a bed of limestone in the edge of the creek and over it about forty feet of dark colored shale. This shale, in other localities, was discovered to abound in kidney ore, and the doposite in question might by some be referred to it, but I more incline to attribute it to the sources above referred it. The deposite of ore occurs on Mr. Thompson's land, near the head of the Brandy Camp. It covers in all an extent of perhaps ten acres, and was proved to be in one place seven feet deep, though its average depth is believed to be not so much. The upper edge of F. XII. seems here to be below the level of the stream; but twenty-five feet higher up e beds of shale, containing large masses of rather coarse nodular iron ore, and at an elevation of about seventy-five feet is a seam of coal, from 3 to 4 feet thick, the upper part of which is cannel coal. About twenty-five feet still higher in the series, lies a bed of limestone characterized by small univalve fossil shells. Indications of a still higher seam of coal occur in the channel of the run above this limestone. Directly under the coal below the limestone, is a layer of excellent fire clay. The land here is owned by a Boston company, who possess some good tracts of ore and coal land in this region. The position of these beds in the series will be readily seen from the section to be presently given. The lower limestone near the conglomerate was met with again between five and six miles to the S. S. E. on Limestone run, which enters Little Toby about that distance south of the turnpike, and heads three miles still further southward. The rock here is of a lighter color, but it contains the same fossil shells and encrinites. This bed was found by one of our party 6 feet thick on an adjacent run, accompanied by a trace of coal directly beneath it supported by a layer of fire clay, containing balls of iron ore. This is about its thickness on Limestone run, where almost immediately below it, lies the upper edge of a bed of sandstone just visible, with many embedded impressions of fossil plants. This stratum was supposed to lie not far above the conglomerate. About fifteen feet over the limestone is a shale abounding in iron ore, the lumps of which are numerous in the channel of the run. It is of various qualities but promises well as far as quantity is concerned.

Signs of coal occur here evidently dislodged from some higher level, but the outcrop of none of the higher strata could be detected. The hill ought to contain, we conceive, at least three seams of coal; but its position, it should be observed, is on the southern margin of the coal measures. The soil of the adjacent country is decidedly good, and we have shown that the region is far from deficient in mineral treasures. The day must come, therefore, when it will sustain a considerable population. The hills are by no means high, rarely more than three hundred feet. Pine timber is abundant and our commoner hard woods attain a very large size. The settlers at present are very thinly scattered.

In collecting the results of the following sections, our practice was to open the outcrop of all the more important beds sufficiently to ascertain their exact thickness by measurement. While obtaining materials for the last, we were much assisted by Mr. Jesse Kyler, from whom we derived much valuable information.

Section of the strata near Horton's, E. side of Brandy Camp creek.

Olive shale.		
Coal, slaty,	2 feet	6 inches.
Bluish sandstone,	20 “	
Black slate,	2	
Coal, of good quality,	2 “	8 “
Grey sandstone,	15 to 20 “	
Bluish grey sandstone,	10 “	
Interval of a few feet, supposed to contain a limestone,		
Olive shale, more than	5 feet.	
Dark sandstone,	7 “	
Coal, the slaty cannel coal variety,	1 “	
Black slate,	1 “	
Bluish shale, containing ore,	8 “	
Greyish sandstone, more than	20 “	
Interval of a few feet, supposed to contain a limestone.		
Coal, of good quality,	2 feet	6 “
Fire clay,		6 “
Bluish shale, abounding in kidney iron ore.		
Interval of about 30 feet, supposed to contain a limestone,	30 “	
Sandstone, more than	2 “	

The abundance of iron ore in the bluish shale near the bottom of the section, and a comparison of the several beds with those found on Limestone run already described, lead to the inference that the interval of thirty feet immediately below, must contain the lower limestone of the section following.

Section of the strata in the hill on the west side of Brandy Camp creek, opposite Horton's.

Olive shale.		
Coal, of good quality,	2 feet.	
Fire clay, good.		
Sandstone,	20 “	
Olive shale,	6 “	
Coal, cannel coal,	1 “	6 inches.
Black slate,	12 “	
Sandy shale,	2 “	

Black slate,	1 feet.
Sandy fire clay,	3 “
Compact blue limestone,	4 “
Sandy olive shale,	20 “
Black shale; here ought to be a bed of coal, which is probably thinned out,	2 “
Blue shale,	25 “
Blue limestone,	4 “
Olive shale,	5 “
Black slate,	2 “
Coal,	2 “ 6 inches.

The bottom of this section are the lowest exposed beds near the level of the creek.

Section of the strata at Kyler's, one mile south of the turnpike, head of Little Toby.

Coal.	
Strata undetermined,	25 feet.
Brownish, olive shale.	
Sandstone,	6 “
Coal.	
Stratum undetermined,	10 “
Olive shale, more than	6 “
Conglomeritic sandstone, dark colored and somewhat calcareous,	3 “
Blue sandy shale,	18 “
Compact limestone,	3 “
Olive shale, upper part a compact whetstone,	8 “
Sandstone, thin bedded and micaceous, of a blue and grey color,	15 “
Blue shale, containing nodules of sulphuret of iron,	4 “
Coal,	4 “
Fire clay.	
Brown shale, containing iron ore,	5 “
Black slate, from	15 to 20 “
Coal, of good quality,	3 “ 6 inches.
Fire clay, sandy.	
Sandstone.	

The lowest of the blue limestones of the second section being discovered nowhere else, and being somewhat sandy, we have supposed it might disappear by degenerating into a calcareous sandstone. The coal seams vary considerably in thickness and quality, showing a transition from glance to slaty cannel coal, or bituminous slates. The second coal ascending, recorded in the first and third sections, appears to have thinned away in the locality of the second section. It may possibly have escaped notice in the stratum marked black shale, as slaty cannel coal, of which it consists where the first section refers, much resembles at its outcrop a black coal slate. None of these coal seams have been worked, nor has any use yet been made in this neighborhood of either the coal, iron ore or limestone, so accessible in the hills. The shales and sandstones, it will be observed, graduate into each other without regularity. The first bed of limestone ascending in the series, contains a small univalve shell, somewhat like a nautilus, which being easily distinguishable from the fossils of the upper and lower limestones, may serve as a feature by which to recognize the stratum. No bed of iron ore was discovered as promising as that in the lower bed of shale, though less abundant exhibitions of ore are not unfrequent in other members of the series.

The neighborhood where the foregoing sections were obtained, is about eight miles from the Clarion river. The country around possesses a pretty good soil, and the surface is such as to admit of the construction of good roads.

Of the coal measures along the line of the Portage Railroad.

The examination of the coal measures bordering the Portage railroad, has led to tolerably definite results respecting the structure and contents of this part of the bituminous coal region. The numerous artificial exposures of the strata have proved of great assistance in identifying and tracing the several mineral beds, but a full and detailed account of the stratification cannot be presented until a series of sections can be published. The form of the Allegheny mountain is that of an elevated table land, bounded by an abrupt slope to the S. E., and descending more gradually to the N. W. The almost level top of the mountain in Cambria county, has an average elevation above the eastern base of about fourteen hundred feet, while the width of the actual summit varies from one to two miles. It is intersected at frequent intervals along its eastern escarpment by long and deep ravines, which mark the passage of the mighty flood that has stripped its summit of all the softer and more destructible strata. Around the heads of these transverse valleys, the width of the table land is contracted, and the real summit of the waters thrown westward of the general front or escarpment of the mountain. In this part of the State the mountain is capped by the massive sandstones and conglomerates of F. XII. In the neighborhood of the Portage railroad, where the mountain is cut by the deep gorge of Blair's gap, the summit level is not attained till we are nearly three miles west of the main front of the mountain. This causes an outcrop of the upper rocks, including the coal, to the eastward of what at first seems the summit, while it is in fact to the westward of the actual crest of the mountain.

Along the line of the railroad, seams of coal have been discovered, and are worked in many places, though we have ascertained the whole number of workable beds to be but four; of these beds, which we will designate in the ascending order by the letters of the alphabet, the first or lowest which we shall therefore call A, shows itself near the foot of plane No. 6, where it is six feet thick, and lies between thirty and forty feet above the sandstone, F. XII. It is here mined to some extent by Dr. Shoenberger. This bed again appears between Croyle's mills and the viaduct; also about half a mile west of plane No. 1, and again on the Conemaugh, three-quarters of a mile east of Johnstown, where it is 4 feet thick, and likewise at the Red bridge, six miles up Stoney creek, where its thickness is 3 feet and 9 inches. Though generally the lowermost coal bed in the formation, we have in two places met with a small irregular seam, about thirty feet beneath it in the series, and very near the upper surface of F. XII.

The second coal seam, B, is mined at Croyle's mills, at the tunnel bend, and at Johnstown. It has everywhere immediately beneath it either a single or double band of limestone, of a thickness varying from 3 to 10 feet. A part of this limestone furnishes at Johnstown, a good hydraulic cement. The average thickness of the coal seam is 3 feet, and it is separated from the coal bed beneath it by from 50 to 80 feet of strata. The outcrop of this bed is visible on plane No. 6, but the seam appearing thin, it has not hitherto been opened, though its true thickness may be greater than the outcrop shows.

The next coal bed of importance ascending, D of the section, shows an outcrop a little below the head of Plane No. 6, and is now mined with some activity by Mr. Lemon, a little west of this on the railroad. At this place it is 4 feet thick, while on all the levels west of the summit, its average thickness is about 5 feet. It preserves very uniformly a distance of 60 feet above the second seam B. Besides occurring in many places along the line of the Portage railroad, it shows itself in the hills around Johnstown, and all along Stoney creek, for seven miles and more above its mouth. On the creek it is found to vary from 2 to 4 feet in thickness.

The uppermost of these four important coal seams, E, though tolerably constant in its thickness, which is from 3 to 4 feet, is irregular in its distance from the bed below it. At the summit, it is separated from Lemon's seam by about 140 feet of other strata, at Croyle's mill by 110 feet, and at Johnstown, by only 44 feet.

Along the valley of the Conemaugh and its tributaries, two other coal beds are indicated by the benches or indentations in the surface, whenever the hills are of sufficient height. The lowest of these beds lies about 200 feet above the fourth of the previous enumeration, and was in one place proved to be a foot and a half thick. Neither of them has been found hitherto sufficiently thick to be valuable.

In this part of the country, the third coal seam, C, to be seen in the engraved sections, does not appear in any considerable thickness, though it is represented probably by a thin band never over 9 inches thick, found in a number of places in a position between B and D.

Three bands of limestone are associated with the several coal seams above described; the first, or lowest, has been mentioned as underlying the second coal bed B of the series; the second bed of limestone was observed at Croyle's mills on the Conemaugh, and at the red bridge on Stoney creek, five miles above Johnstown, varying in thickness from 3 to 6 feet. Its relation in position to the coal beds of the series at each place is obscure, underlying a coal bed which is supposed to be the bed D, though that bed is accompanied by limestone at no other locality. This has been measured in three localities, two of which are on Stoney creek. The third bed of limestone has been ascertained to be in one place 3 feet thick, and sixty feet above the coal bed D, and in another neighborhood (on Stoney creek) 2½ feet thick, and twenty-nine feet above the coal.

Iron Ores.

Indications of iron ore occur in the red shale, F. XI., on the eastern side of the mountain, in Burgoon's gap, where there is a large spring depositing bog ore. Loose pieces of ore accompany the same formation near the head of Plane No. 7, where some unsuccessful diggings were made by us. A similar spring, occupying a corresponding position to that at Burgoon's gap, is said to exist three miles south of the railroad. Though various localities bordering on the line of the railroad were explored for ore, but two places were met with worthy of description for the amount of ore developed, and both of these need further investigation before their value can be positively ascertained. One of these is on the level between Planes No. 3 and No. 4, where there occurs a bed of soft shale 5 feet in thickness, apparently one-fourth of which consists of ore. Its position in relation to the accompanying strata is shown in the following *section:*

Dark friable shale,	20	feet.		
Coal,			6	inches.
Black slate,	1	"	6	"
Sandstone, hard and ferruginous,	1	"	6	"
Friable shale, nearly one-fourth ore,	5	"		
Slates and flaggy sandstones,	20	"		

At the head of plane No. 3, a mile from this, the ore-bearing band is replaced by 5 feet of limestone, probably the third limestone of our previous enumeration. Such replacements of ore and limestone are by no means of rare occurrence. The next locality displaying a somewhat promising amount of ore, is on Stoney creek, about half a mile below the red bridge. Here, at an elevation of eighty feet, in a steep bank on the north side of the stream, we find numerous nodules of good ore closely bedded together in a stratum, 1 foot thick. Directly under this is a ferruginous limestone, in nodular masses, the whole 2½ feet thick, and this is followed by 2½ feet of fire clay. Lower in the series about thirty feet, we find a bed of coal, B, 4 feet thick, underlaid by 6 feet of limestone, and after a space of ten feet below this again, occurs a mass of shale, one layer of which, 1 foot in thickness, presents a total thickness of 5½ inches of good ore, traced by us one hundred yards along the foot of the hill.

The Coal Basins south of the Conemaugh.

Leaving the vicinity of the Portage railroad and Johnstown, and directing our attention in the next place to the country between the waters of the Conemaugh and the southern line of the state, I shall notice first the characters and position of two great anticlinal axes, the knowledge of which is essential to a correct understanding of the region. The first axis of elevation, going westward, in the latitude of the Portage railroad, is finely exposed at the viaduct, eight miles E. of Johnstown. At this place the strata have been sufficiently lifted to bring into view the red and variegated shales of F. XI. A spectator looking westward from the summit of the Allegheny mountain, at the head waters of Shade creek, may trace the course of this axis by a broad ridge or line of highlands, stretching to the S. S. W. towards Jennerville. It is difficult to settle exactly the point at which this axis flattens away, but it is observed at the mouth of Roaring run on the Quemahoning, and on Stoney creek below the mouth of Paint creek. This line of upraised strata, and the axis of Negro mountain, traversing Somerset county, are unquestionably the primary cause of the scarcity of the coal measures around the town of Somerset and along the eastern base of Laurel hill. From the same station on the Allegheny mountain, a spectator sees between him and the ridge above mentioned, a rather larger and better defined range of high land running parallel with the first. This owes its elevation to a second anticlinal axis which crosses Shade creek, between Huskin's run and Roaring fork, passes then between two and three miles east of Stoystown, and ranges east of Somerset, through the middle of the Negro mountain, which commences here as a broad and regular ridge, running to the S. S. W. Near the southern line of the state, the Negro mountain separates into two slowly diverging crests, caused by the gradual rising towards the south of its axis of elevation, bringing the easily denuded red shale of F. XI. to the surface, as may be seen where the National road crosses it. This axis could not be definitely traced northward of Shade creek, though observations made at the forks of Paint creek render it highly probable that it ranges far into the wild district between Shade creek and the Portage railroad. Should it maintain its usual straight course in this direction, it would coalesce with the Allegheny mountain in the neighborhood of the railroad summit.

From Johnstown to Somerset, the rocks which saddle or overlie these axes appertain exclusively to the coal measures, except in the bottoms of the ravines where the underlying strata disclose themselves. The western axis subsiding to the south, and the other declining as steadily towards the north, they embrace between them, where they pass each other, the narrow basin of Stoystown. Here a moderately perfect section of the rocks was procured, from which we find a very similar series of strata to that observed along the Conemaugh.

In this narrow central basin of the county, the coal bed A has been developed in many places along Little's run, four miles north of Stoystown. The bed here contains 5 feet of good coal. Separated from this by 100 feet of strata, we find the next overlying coal bed, B, here 2½ feet thick, and resting immediately on its attendant layer of limestone, from 3 to 4 feet thick. The place where this appears is two and a half miles north of Stoystown, at Lohr's limestone quarry.

The coal bed C is worked by Mr. Kimmel, at Stoystown, where it is 4 feet thick, and overlies the last at an interval estimated to be from forty to fifty feet. The identity of the bed at Kimmel's with that at Lemon's on the Portage railroad, established by a comparison of the stratification, is borne out by a similarity in the character of the seams themselves.

The coal seam E seems to be divided, in the vicinity of Stoystown, into two beds eight feet apart, and each of them 3 feet thick. The lowest of these is worked by Messrs. Cooper and Graef, on a little branch of Oven or Breastwork run, about two miles N. E. of Stoystown.

There is an outcrop of apparently a large coal seam on the turnpike, east of Stoystown, overlying the uppermost of these beds, at a distance of about ninety feet. Benches or indentations on the surface indicate the existence of two or three other coal beds between this and the summit of the highest hills, though the localities where the coal has been opened are so scattered and few as to interfere with all attempts at placing them accurately in the series.

Comparing the order of succession of these beds at Stoystown with the series which presents itself on the Conemaugh, we perceive:

First, that a small quantity of iron ore reposing upon coal A, at the railroad summit, and near Croyle's Mills, becomes in the vicinity of Stoystown, a regularly formed band of nodular ore. This is evident from fragments seen in the bed of the small creek on which Little's coal bed is opened.

Secondly, that a band of sandstone seen over the same coal bed at Plane No. 1, and at Stoney creek bridge, appears in corresponding place over Little's coal.

Thirdly, that the small coal bed found near Johnstown, above the same seam, is represented by two small beds seen under the limestone which attends the coal B, three miles north of Stoystown.

Fourthly, that the same bed of limestone accompanies coal B in both localities.

Fifthly, that the sandstone over the coal bed B retains not only its relative position, but its average thickness, about 30 feet, and also its characteristic features in both districts.

It would seem that all these strata in the small Stoystown basin gradually rise as they pass south lifted, in all probability by the widening and rising of the Negro mountain. This elevation of the whole basin is made evident at Somerset, by the paucity of the coal in that neighborhood, the bottom strata of the coal measures having been there brought up to the level of the lower streams, and many of the superincumbent beds having been removed by denudation.

All traces of the viaduct axis disappearing in the neighborhood of Jennerville, we have from Somerset southward, but one wide basin between Negro mountain on the east and Laurel hill on the west.—The synclinal axis or line of meeting of the western and eastern dips is far from ranging centrally through this basin. Its course is immediately along the base of Laurel hill, coinciding very nearly with Laurel hill creek, which like so many other streams, flows along the line of the axis, while its distance, on the other hand, from the western foot of Negro mountain, is between five and six miles. Contrary therefore to the general rule, the western or north-western dips in this basin are much gentler than the south-eastern. Inasmuch as the whole body of the coal measures in the deeper part of the basin, affords but 4 or 5 seams of coal, and these of deteriorated thickness, it is obvious that in the vicinity of Somerset, so near the eastern margin of the trough, the conglomerates and sandstones of F. XII must approach very near the surface. These rocks show themselves, indeed, on the western flank of the Negro mountain.

Iron ores of the Stoystown basin.

Before quitting the details of stratification in the Stoystown basin, we must make a brief reference to its iron ores, respecting which there is but little to say. A small band of ore near Somerset, and another 5 inches thick, occurring under Cooper's coal vein, are the only deposits visible. There are, however, important localities on

Shade creek, Paint creek, and Wells' creek, within the same general district, but not strictly within this basin which may be noticed in this place.

Although the old Shade furnace was supplied with a poor ore, which led to its abandonment, there occurs an abundant deposit of pretty good ore, recently discovered two miles further up the stream. It is in coarse nodules, some of which are of great size, though a small layer of a finer quality, and a few inches thick overlies it in a compact shale at a distance of four or five feet. Between ten and fifteen feet above this latter layer, there is a thin seam of coal about 16 inches thick. No other coal bed, and unfortunately no limestone, has yet been, or is likely to be discovered in this immediate neighborhood. Notwithstanding the scarcity of these materials, the spot seems a sufficiently favorable one for the manufacture of iron, the ore seeming to be good and abundant, and fuel, both charcoal and mineral coal, being procurable at no great distance. A small furnace is therefore now erecting at this place. The geological situation of this ore is in shale, resting directly on the upper surface of the coarse conglomerate F. XII. Indications of the same ore occur in a corresponding position, the whole way from the old Shade furnace to the mouth of Shade creek.

At Lambert's mill there is a bed of coal 3 feet 7 inches thick, and over it 12 feet of dark shale, containing a yellowish fine grained ore, in flattened nodules, weighing from ten to twenty pounds. The aggregate thickness of the ore, in the whole 12 feet of shale, is estimated at 2 feet. Ten or twelve feet beneath the coal bed, lies a band of limestone, in thickness about 2 feet.

The promises of ore at the forks of Paint creek are still more flattering. There is likewise good coal, and a band of limestone and excellent water power at this place. The hill between the two streams which unite at the Falls of Paint creek, exposes especially on its northern side, a bed of shale and sandstone, between 20 and 30 feet thick, resting on a seam of coal 3 feet in thickness. In this shale are many layers of nodular iron ore. The lower bands are generally thin and flaggy, the rounder nodules being confined to the upper part. The aggregate thickness of the ore at this place was estimated at 2½ feet; but it is not probable that it maintains this abundance over a wide space, as this species of ore is never very uniform. Lower down the main stream occur two other layers of ore, referable apparently to the upper beds of F. XII. One of these is a band 7 inches thick, of excellent ore; the other is coarser and 8 inches thick.

A fourth locality, important for its iron ore, is on Wells' creek, five and a half miles N. E. of Somerset. Here a layer of limestone occurs in the bed of the creek, resting on a blue sandstone, which forms the bottom of the channel. The limestone is said to be in all 6 feet thick, though only two feet are exposed. A coal bed showing a promising outcrop, appears a few feet above the limestone, and indications of other coal seams present themselves further up the hill. One of these upper beds has been worked. At the top of the hill, nearly three hundred feet above the stream, in a sterile tract of a few acres, many pieces of a very rich red ore have been met with, but the quantity remains unknown. This spot deserves examination on the part of the owner, Alexander Hunter. Should the ore be abundant, its value would be enhanced by its proximity to another deposit of ore on Stoney creek, with which it might be worked. A furnace is much wanted in this section of the country, while charcoal and water power are both plenty.

The ore just referred to on Stoney creek, is at the "Silver diggings," about two miles above the mouth of Wells' creek. Here a shaft twenty-eight feet deep was found, which passed through two bands of ore, the lowest of which lying lower than the bed of the creek, cannot be worked. The upper, though a small seam, consists of very pure ore. This is of insufficient thickness by itself, but at the upper edge of the shaft there is another layer of ball ore, apparently of ample size, possessing an aggregate of ore equal, we think, to one foot.

Quitting now the middle or Stoystown basin, and directing our notice to the larger parallel trough on the S. E., or that which lies between the axis of Negro mountain and the ridge of the Allegheny, we have to remark that this basin in all probability takes its origin on the table land of the Allegheny, south of the summit of the Portage railroad. Owing to the wilderness state of the country for some miles south of the railroad, and the extreme paucity of exposures, very little could be accomplished in developing its geology. This tract, as far south as the line of Somerset county, has the character of a barren table land. The first neighborhood important for its mineral deposits which we meet with in passing south, is that on Shade creek already described. The localities here, though appertaining properly to this basin, and not to that of Stoystown, were referred to in another connection for the sake of describing all the iron ores of the neighborhood under one general head. The anticlinal axis, separating the two basins, is first obviously recognized on Shade creek between Huskin's run and Roaring fork, where the red and green shales of F. XI. are plainly brought into view in the banks of the stream. From "Miller's breast works," the whole way to Shanksville, and along the Stoystown turnpike, we can generally trace four benches in the hills indicative of as many coal seams. Three of these are plainly visible around Shanksville, though the coal has not been opened. This little village is on *Stoney creek*, two miles further east than the position given it by the State map.

Along the Allegheny mountain, following the eastern outcrop of red shale F. XI., the ore of this formation was recognized in many places from Conover's fork of Shade creek, the whole way to the Maryland State line. It is well marked by the springs depositing bog ore, which so generally issue from this stratum. The appearances at Conover's fork, indicate sufficiently the general character and relations of the deposit throughout its range.

Ascending the mountain from the west towards the head of the stream, the lowest bed of coal, A, is seen cropping out within two and a half miles of the summit, succeeded by the rocks of F. XII. rising a little faster than the surface. East of the outcrop of F. XII. which is not wide, the softer red strata of F. XI. appear and form an extensive smooth flat. This terrace of the red shales, notwithstanding its elevation, generally affords a good arable soil. It varies in breadth, and is sometimes bounded on the east by outlying patches of the harder rocks of F. XII. in the form of knobs. At the western base of these knobs, a gentle westerly dip of the rocks throws out on the surface of the red shale, a line of copious springs charged with ferruginous matter. These springs flowing from the ore layers near the top of the red shale, deposite the oxide of iron in the form of bog ores, in deep circular beds.

At Conover's fork, the line of the springs is a mile west of the summit, the red shale appearing around them. The overlying beds of F. XII. are here about fifty feet thick. Though the existence of a band of solid ore, in the upper layers of the red shale, is only inferred from the circumstance of these ore springs, the appearances are such, that diggings should be made along the margin of F. XII., where the escarpment of this rock begins. The hard ore may perhaps occur in places so near the surface, in some parts of the flat, as to be accessible by merely uncovering or stripping. This is the state of things on Laurel hill, at Garey's.

The strata in the Allegheny mountain generally dip to the westward, at an angle varying from 15° to 20° causing the overlaying coal measures to ascend the western slope to within a mile and a half of the eastern crest. But where deep valleys of denudation intersect the mountain obliquely on its eastern escarpment, the coal is made to appear occasionally as if it outcropped *east* of the main summit of the ridge, though its true position is still westward of the general crest.

Transferring our attention now to a more southern portion of the eastern basin, (that of Berlin and Salisbury,) we perceive that the coal measures along Castleman's river between Salisbury and the mouth of Flaugherty's run, are confined almost entirely to the hills on the western side of the river, the rocks of the eastern bank, though at the west foot of the Allegheny mountain, being chiefly the sandstones and conglomerate beds of F. XII. The steepness of the western dip along this part of the eastern side of the basin will explain two features of some importance. One of these is the position of the synclinal axis or bottom of the trough, which lies considerably east of the centre of the valley; the other is the greater thickness of the coal measures in this vicinity compared with the tracts further north. We consequently discover here the large bed of coal, high up in the series, which, from the shallowness of the basin elsewhere, has not been preserved from denudation. This coal lies near the top of a long hill between Castleman's river and Elk Lick creek. The Negro mountain axis, which lifts to the surface, in Maryland, formations as low in the series as F. IX., subsiding to the north and the synclinal axis of the basin rising, the trough of the coal measures becomes gradually shallower in this direction. One consequence of this rising of the bottom of the basin northward is the disappearance of the large coal seam at Castleman's river.

An opportunity for comparing the relative thickness of the strata lying above and below the water level in the centre of the basin, is furnished by a salt boring on Elk Lick creek, three miles above its mouth. There appear to be about 400 feet of coal rocks below, and nearly the same amount above the level of the stream; though the relative number and thickness of the included coal seams is different, for while only three beds of any note, having an aggregate thickness of 10 feet, were noticed between the bottom of the boring and the water level, there are no less than seven beds, though some of them thin ones, amounting to 20 feet of coal, in the strata between the water level and the tops of the hills.

By comparing these beds first with the series along Castleman's river, in the next basin to be described, and then with those on the Conemaugh and in the Ligonier valley severally, we find a progressive dimunition of the intervals which separate corresponding coal beds as we proceed from the S. E. towards the N. W. We also find, as far as these basins are concerned, an improvement in the number of the workable beds in the same direction. Notwithstanding these changes, we notice a remarkable permanency both in the number of the coal seams and in their accompanying layers of limestone and iron ore. Thus, the lowest coal seam, designated A on the engraved section which accompanies this report, is in the eastern or Berlin basin 3 feet thick, and overlaid by 100 feet of sandstone. The ore immediately above it, on the Conemaugh, is absent in the neighborhood of Castleman's river. The next bed of coal, B, rests everywhere directly upon a layer of limestone, each of these being in this place 5 feet thick.

A seam of coal holding a corresponding position in the series, occurs at the winding falls of Elk Lick, on the side of the Negro mountain. Here the usually accompanying limestone is not seen. We generally find beneath this coal and limestone a massive stratum of sandstone. This causes the falls of Elk Lick, where the coal consists of two beds, the uppermost 2 feet, the undermost 2 feet 3 inches thick, separated by 1 foot 6 inches of fire clay. The whole reposes immediately upon 5 or 6 feet of fire clay, and this again upon the thick mass of sandstone.

The falls of Elk Lick is a succession of many small and rapid leaps, winding in a long descent through a narrow irregular channel in the sandstone; the rocky walls sometimes overhang the stream, which is then darkened by the meeting boughs of the trees and the tangled stems of the laurel, which in many places make an almost impenetrable thicket. The defile itself is alternately contracted into short narrow passages and widened into more spacious chambers. The whole scene, though of limited extent, is striking for its novel and picturesque beauty, and in perfect keeping with the wilderness around. The water power at this spot derives value from the discovery of a bed of iron ore to be mentioned presently.

The third coal of importance, (E of the section,) is between 2 and 3 feet thick. It is a rather poor coal, and like the former, reposes upon a bed of limestone 5 feet thick. They show themselves near the level of the stream, at the old salt boring on Elk Lick. Between the two coal seams, B and E, occur two other smaller beds, C and D, along the edges of the basin. These correspond with beds in the Ligonier valley, and on the Conemaugh.

The next bed in the ascending order, F, is here 4 feet thick and of good quality. It is accompanied by three insignificant seams, the overlying one being 2 inches thick, while the uppermost of the inferior ones is 12 inches. Elsewhere, in the other basins to the N. W., it assumes a more trivial thickness. The coal bed G, also a widely diffused stratum, measures 1 foot 6 inches in thickness.

Still rising in the series, we find another, though a very thin coal bed, H, said to be 1 foot thick. This bed becomes 3 feet thick in the basin between Laurel hill and Chesnut ridge. Still ascending the hill, on the east side of Elk Lick creek, which has furnished us with all the details of the foregoing section, from E upward, we meet with the great bed, I, 9 feet in thickness. Indications of this appear in other localities near the Maryland line. The same stratum occurs in the series at Ligonier, where it is underlaid at a distance of twenty feet, by a bed of limestone measuring 6 feet; this limestone has not been yet detected on Elk Lick. Though sufficient progress has not yet been made in our researches, to enable us to compare with any certainty, the stratification of the great coal field west of Chesnut ridge, with that of the basins we are now describing, a sufficiency of evidence exists to render it highly probable, that the great coal seam before us, is identical with the widely diffused valuable coal bed so well exposed at Pittsburg.

Two other coals, K and L, are indicated by their smut, the lower evidently a large bed.

Limestone beds.

With regard to the limestones, three distinct layers occur along the centre of the basin. The uppermost caps the hill which contains the large coal seam between Elk Lick creek and the river. The quality of the rock is good, but its thickness, owing to denudation, could not be ascertained. The second descending, is a foot and a half thick, and overlies the thin coal bed, H. The third is seen in many places along the level of the creek. It dips beneath the stream at the salt boring; and half a mile further down the creek, it has been opened at an elevation of fifty feet above the level of the creek.

This difference of level, attributable simply to the inclination of the strata, led us at first to suppose that there were here two separate beds of limestone, but this proved to be an error. The thickness of the bed is 5 feet, its quality is good. The limestone, we have already stated, supports the coal seam E.

Upon Castleman's river, at the mouth of Buffalo Lick creek, there is a fourth layer of limestone, not noted in the salt boring. As more or less uncertainty attaches to all results derived from narrow perforations of the strata, like these borings for salt, the absence of this bed in the well in question, may be only apparent. This limestone at the mouth of Buffalo Lick creek, where it is 5 feet in thickness, supports the coal bed B.

While tracing the limestone beds of this basin, it was a problem of some interest to determine, whether the rock could be sufficiently indicated by the nature of the immediately overlying soil. Viewing a peculiar orange-yellow earth as derived directly from the decomposition of the limestone, we succeeded, by adopting it as our guide, in developing two layers of the rock in the vicinity of Berlin, and pursuing them along their outcrop for a considerable distance, the soil proving in every instance, an unerring clue to the subjacent limestone.

Iron ores.

The most important deposite of iron ore hitherto brought to light in this basin, is that of the Elk Lick falls above referred to. There are here three layers of ore. The lowest, measuring 1 foot 4 inches, is a nearly solid bed, merely divided into blocks rounded at the edges. The other two overlie the first at a distance of two feet, and together contain as much ore as would be equivalent to a solid band about 4 inches thick. For the composition and quality of this ore consult the description and analysis given in the final chapter. An ore, supposed to be the same band, was discovered two miles further down the creek. Several thin seams of ore likewise occur on Tubmill run, half a mile below the saw mill, but they are not of sufficient importance to attract attention. At another place on the same stream, ore is said to have been opened in a position twenty-five feet below a coal seam, 3 feet 3 inches thick, identified with that at the falls; this ore is stated to amount to 15 inches. No indications of the iron ore of the red shale F. XI., were met with along Negro mountain; but the calcareous sandstone of that formation, is traceable throughout its whole length, being well exposed at the gap at Castleman's river, where a run descending from the south, cuts the stratum for a considerable distance.

Of the third or western Somerset basin.

The basin next to be described, is that included between the viaduct and Negro mountain axes on the east, and the axis of Laurel hill on the west. Our present purpose in this description being not so much to exhibit all the details of the geology as to offer in a concise form some of the general results of our researches, I propose to allude but casually to the localities between the Conemaugh and Jennerville, referring them to the series on the Conemaugh, and to dwell more at length upon the better developed stratification seen along Castleman's river and Laurel hill creek.

Before passing to the consideration of the coal measures of this basin, we must allude to a few localities where the rocks immediately underlying them exhibit some features of practical interest. The strata forming the eastern flank of Laurel hill, which bounds this basin on the west, consist of the sandstones and conglomerate of F. XII., while the redshales, F. XI., saddle the summit of the ridge. These latter beds likewise appear along the higher slopes of the mountain wherever the surface is gashed by deep ravines. At the foot of the mountain or western edge of the basin, the inclination of the strata rarely exceeds 5° or 7.°

Formation XI., as it appears on Laurel hill, is a series of alternating red shales and red sandstones, including a massive stratum of calcareous sandstone passing into sandy limestone, the upper surface of which is about one hundred feet below the top of the whole mass. The entire thickness of F. XI. on the Conemaugh is somewhat more than two hundred feet; this it retains as we pursue it southward, though the composition of the several members of the formation undergoes a material change. While this important and well characterized stratum retains generally, in other sections of the State, the character of an argillaceous red shale, this and the immediately adjacent belts contain a larger proportion than usual of alternating beds of compact, grey and red sandstones, which increase in relative quantity as we proceed southward. The shales becoming more siliceous, the calcareous sandstone, above mentioned, grows also more calcareous, passing in some places into an excellent limestone occasionally thirty feet thick.

The iron ore, so frequently to be met with in the upper part of this formation, is not seen on the Conemaugh, but following the belt southward along Laurel hill, we find many signs of it, as where the Johnstown and Ligonier turnpike crosses the ridge. At this point the quality of the ore is not promising, while, upon the western slope of the mountain, the limestone, which underlies it, is quarried and used to some extent. This calcareous rock shows itself likewise at the crossing of the Somerset turnpike, but unaccompanied by indications of the iron ore which ought not to appear in contact with it, but in its vicinity. It exhibits here, as in many other places, in a very remarkable degree, the action of violently and irregularly eddying currents at its formation, the often massive beds showing innumerable oblique and meeting layers that plainly mark its unequal deposition.

Still further south, on the summit of the mountain, at the head of Garey's run, the iron ore of the red shale is exposed in a very accessible manner. It occurs on a large tract, the surface of which slopes gently and uniformly to the S. E. in obedience to the general inclination of the strata, the ore band occupying the uppermost layers. This ore has been used at Fayette furnace, on Indian creek, being got by stripping and turning up the soil and superficial shale to the depth of from 1½ to 6 feet. At a spot where we caused the ore band to be exposed, it measured 8 inches in thickness and proved to be of excellent quality. It is said to have occurred in some spots as thick as 3 feet when it was worked. The line of highest land along the mountain ranges a little west of this tract. The crest consists of F. XII., a somewhat lower parallel ridge of which two miles further east, bounds the red shale tract on the lower side. In a little ravine which intersects the easternmost of these sandstone ridges appears the iron ore in large slabs, lying loose in the channel of the stream. This is on the property of Mr. John Dull, about four miles S. S. E. from Garey's. Some of the slabs of ore are 6 inches thick. Appearances here indicate the existence of two layers of the ore. A seam of excellent coal, 2 feet 6 inches thick, lies over the ore at a distance of about thirty feet. This bed probably belongs to a thin lower group of coal rocks which, in this southern section of the State, interpolate themselves as a separate formation between the upper surface of the red shale and the lower limit of F. XII. These we shall have occasion presently to describe, when treating of the corresponding part of the next western or Ligonier basin, where they are more developed. They make their appearance in the present basin at least as far north as the neighborhood of the Stoystown turnpike, where, at the head of Jones' creek, we find these carbonaceous rocks regularly interposed, with a thickness of about thirty feet between the red shale F. XI. and the sandstone F. XII. Here the enclosed coal seam is only 9 inches thick; it lies about thirty feet above the iron ore of the red shale and reposes immediately beneath the rocks of F. XII., the total thickness of which, at this place, does not exceed thirty feet.

The iron ore of F. XI. is seen near Henry Whipkey's, on the Clay turnpike, where it occurs at a small distance beneath F. XII. in several bands, one of which measures 5 inches, and another 2 inches. Here, however, more digging than we had time to bestow was requisite before we could decide the exact position and value of these layers. South of the Youghiogheny in this basin, this ore has not yet been minutely traced by us, but of its existence we have had evidence in the bog ore deposites of the springs. These are seen on the other side of the mountain, at the crossing of the Turkey Foot road over a branch of Meadow run, which descends into the basin next west.

Formation XII., along the eastern flank of Laurel hill, exhibits a variable composition and thickness. On the Conemaugh it has the character of a coarse sandstone and is nearly 200 feet thick, whereas at Jones' mill run, west of Somerset, its thickness is reduced to 30 feet, and it is underlaid, as already mentioned, by as many feet of coal rocks holding a thin band of coal. On Ben's creek, but a few miles south of the Conemaugh, it includes massive beds of siliceous conglomerate, which is indeed the true type of this formation generally throughout the State.

The formation has a thickness of 100 feet on Drake's run, a tributary of the Youghiogheny. Overlying it is a bed of coal varying from 1 to 3½ feet in thickness, separating this rock from a bed of brown sandstone. In the next basin to the west this latter stratum, approaching in character to the underlying F. XII. is readily confounded with it, the coal seam constituting the only clear line of division. This is the coal seam A, of our section. On Gabriel's run, south of the Youghiogheny, this seam is 2 feet thick, consisting of excellent coal. Here the overlying rock is no longer a brown sandstone, but a slaty micaceous sandstone, 25 feet thick.

A rude section was obtained between the forks of Ben's creek which exhibits the coal seam, B, of a thickness of 4 feet reposing upon its limestone, here 3 feet in depth; above this, sandstone and slates supporting the coal bed C, also 4 feet in thickness, and upon this again a mass of olive slate overlaid by a third coal bed referable to D, of our sections. The limestone under the coal B, is well exposed on the new turnpike connecting Johnstown and Somerset. In the short distance of a few feet, the rock passes into iron ore, its carbonate of lime being replaced by carbonate of iron. The ore is of good quality. The coal C, appears for a quarter of a mile along the road leading from the turnpike to Ligonier; the grade of the road just equalling the dip of the strata. In this thinly peopled district the exposures are few and the rocks therefore difficult to trace.

Along Roaring run, from its mouth to the bridge on the Jennerville road, a sandstone, the upper member of F. XII., fills the bed of the stream. A small exposure occurs at Griffith's mill, near the road. Descending the road from the north to the bridge, we cross the outcrop of a coal seam, which was ascertained to be the bed A, of our sections. It is mined by Mr. Bowman, two miles N. E. of the mill, where it yields three feet of rather indifferent coal. Slate and shale occur above it through a thickness of 50 feet. Covering the surface of these slates we found much iron ore of excellent quality. In the hill west of this a massive sandstone, 25 feet thick, overlies these rocks. This, following it still westward towards the middle of the basin, seems to change in character, and we are therefore deprived of any key it could afford us to the overlying coal beds. The facts collected go to show that the coal bed B, 4½ feet thick, opened by Mr. Richard two miles west of the bridge, and a band of limestone 3 feet thick underlying it, range extensively through the basin, their outcrop appearing along the streams. Above these we meet with indications of several other coal seams, the exact number and thickness of which could not be escertained. At the mouth of Lick run, on Ben's creek, is a limestone, 5 feet thick, apparently in this part of the series, the true position of which could not be settled for want of sufficient exposures. Though this may possibly be identical with the limestone under the coal B, we are disposed to view it rather as the band underlying the bed E.

Between Castleman's river and Laurel Hill creek the coal series is much thicker than in the country north of Jennerville; it is moreover better developed, from the greater height of the hills bordering the streams. Near the centre of the basin, in the vicinity of the

"Turkey foot," the coal measures have a thickness of nearly 700 feet, while further to the north the basin becomes shallower and the coal seams inferior in number and thickness. By compiling the measurements obtained in numerous places along Castleman's river and in a few diggings made on Laurel Hill creek, we have obtained a general section shewing the following to be the order of stratification, as exhibited in the engraved sheet accompanying this report.

Where the basin is deepest it contains eight beds of coal, the four lowest of which are opened in various places. These four are identical with the beds exposed on the Conemaugh.

Section at Husband's mill, Laurel Hill creek.

Sandstone.		
Coal bed D, comprising 4 feet of coal.		
Coal, tolerably good,	2 feet.	
Slate,		2 inches.
Coal,		6 "
Fire clay, good,	1 "	
Coal,	1 "	6 "
Fire clay,	2 "	
Calcareous sandstone,		6 "
Iron ore, of fair quality in large balls, in close contact,		9 "
Slaty sandstone,	7 "	
Iron ore, good,		2 "
Sandstone,	2 "	
Fire clay,	1 "	
Bluish shale,	6 "	
Coal bed, C, good,	3 "	
Strata undetermined,	40 ? "	
Bluish shale,	10 "	
Black slate,	3 "	
Coal bed, B,	1 "	6 "
Fire clay,	1 "	
Limestone, good,	4 "	
Slaty sandstone,	15 "	
Shale, with *iron ore* in small bands, whose aggregate thickness is sometimes 2 feet, but variable,	5 "	
Shale,	5 "	
Creek, level.		

Starting at the conglomerate and adopting as usual the ascending order, the first coal seam which we meet with is the bed A, which shows itself only along Castleman's river, near the stream. It is thickest at Schoff's bridge, where it measures 22 inches. Its distance from the subjacent conglomerate is about 30 feet, a massive sandstone separating them.

The next bed of coal, B, lies near the base of the hills. It is everywhere underlaid by its limestone. This coal is distant from the lower seam, A, about seventy feet; it is 4 feet thick on the river, (where it consists of three bands,) and 1 foot 6 inches thick on Laurel Hill creek. At the former place the limestone is 8 feet thick; at the latter only 4 feet. About 22 feet below the limestone occurs a thin seam of coal supporting a band of iron ore. This is seen on the west bank of Castleman's river, a quarter of a mile above the fording at the mouth of Zook's run, and the same band again shows itself a little above the water level on Laurel Hill creek, at the old salt boring, where in 5 feet of shale there is upwards of 1 foot of ore.

On Spring run, which empties into Castleman's river just below the great bend, below Zook's run, ore occurs in the form of slabs and balls in a mass of olive shales and sandstone, 15 feet thick. These strata lie twenty feet above the coal seam, B.

Above the coal B, about thirty feet, occurs the next seam C, at the mouth of Cox's creek. These are forty feet apart on Laurel Hill creek, and sixty feet at Turkey foot. At the former place the bed C is 2½ feet thick, and at the latter from 3 to 4 feet.

The coal bed D, was only found upon Laurel Hill creek, where, ten miles above its mouth, its outcrop is seen twenty feet above that of the bed C. Here it includes three bands, and is 4 feet thick, resting upon 11 feet of sandstone. This sandstone contains good nodular iron ore in two bands, seven feet asunder, the whole amounting to 11 inches in thickness. On Drake's run, about eight miles S. W. of this locality, there occurs a band of iron ore, at least 9 inches thick, occupying a corresponding position in the strata. Here the coal bed C is also recognized, lying at some distance below the ore and having its usual thickness of about 3 feet. A layer of iron ore, similarly situated in the series, is found at Henry Whipkey's, on the "Clay turnpike," at the foot of Laurel hill. An ore referable to the same band, was discovered in abundance on Gabriel's run, south of the Youghiogheny. A comparison of this coal seam, D, as it occurs upon Laurel Hill creek, with the bed B, on Castleman's river at the mouth of Zook's run, showing the close similarity which sometimes prevails between distinct strata, may impress a useful caution upon those who would try to identify layers merely by their internal resemblance. The seam B consists of,

Coal,	2 feet.	
Slate,		2 inches.
Coal,		6 "
Fire clay,	1 "	
Coal,	1 "	6 "

While the bed D shows these divisions:

Coal,	2 feet.	
Black slate,		8 inches.
Coal,		4 "
Black slate,	1 "	
Coal,	1 "	6 "

The coal seam E is seen, sixty feet above the bed C, opposite Phillippe's, on Castleman's river, four miles below Cox's creek. It is generally about 20 inches thick, and at Spring run, (not on the map,) reposes upon 2 feet of limestone, the stratum which usually supports it.

The coal bed F, at the same place, occurs over E, separated by about 50 feet of strata, embracing in their lower part a mass of olive colored shale, which encloses a few balls of iron ore.

The next seam, G of the section, is indicated by a conspicuous bench which encircles the tops of the highest hills. That singular natural mound called Fort Hill, is not quite high enough to receive this bed, though its sides are indented by the outcropping of the other lower seams. The distance of the bed G above F is about ninety feet, the interposed strata being in the upper part flaggy sandstone and in the lower, slates and shales, some of which, judging from the soil, are red.

A hundred feet higher in the series, lies the eighth coal bed, H, indicated by a well defined bench near the summits of the highest hills. No opportunity presented itself for determining the thickness and quality of this stratum, or for ascertaining the existence of the limestone, elsewhere found in this part of the series.

The occurrence of this seam, H, so near the tops of the highest hills, accounts for the absence of the great bed I, seen, in the Ligonier and Berlin basins, at an elvation above it averaging fifty feet.

There is a bare possibility of its existence in some of the very highest knobs in the centre of the basin. There is also a very slight hope of finding this great bed in the northern part of the basin near the Conemaugh, south of Johnstown, where, throughout a range of several miles, a conspicuous coal bench is visible in many places on the very highest land, in a position agreeing closely by measurement with that which this bed ought to occupy, adopting the Ligonier section as our standard.

In the above account of the coal seams of Somerset county we have restricted our description chiefly to the main coal formation which rests above the conglomerate and sandstones constituting F. XII. But there exists, as we have mentioned, a lesser group of coal rocks somewhat lower in the series, interposed between F. XII. and F. XI. These first assume a notable importance in this basin, immediately east of Laurel hill; but as they expand to greater thickness in the next trough to the west, that of Indian Creek valley, we shall reserve a more detailed notice of them for the close of our description of that basin.

Coal basin between Laurel hill and Chesnut ridge.

The next tract of country which demands description in our progress westward, is the well defined coal basin bounded on the east by the mountain ridge called Laurel hill and on the west by the similar chain of Chesnut ridge. These bounding mountains are broad, single, parallel and anticlinal ridges, of even summits and remarkable regularity of outline. While their crests rarely have an elevation of more than nine hundred feet above the adjoining valleys, they rest upon a base varying from three to five miles wide. They are both of anticlinal structure, a single axis of elevation traversing the whole length of each. The lowest rocks of our great secondary series uplifted to the surface at these axes are the sandstones constituting F. X. These rise to the day only near the crest of each mountain; nor do they always appear, the overlying red shale F. XI. and the sandstones F. XII. often folding over them at the summit. The red rocks of F. IX. show themselves only in the middle of the mountain at its base, where either ridge is traversed by a deep notch or mountain gap; nor do they ever rise high above the water level, but form a low arch directly at the anticlinal axis. The formation thus shows itself at the gaps of the Conemaugh and the Youghiogheny. The anticlinal structure of these ridges, combined with the gentle inclination of their strata, causes their flanks to consist in a great measure of one formation, the sandstone and conglomerate beds of F. XII., dipping nearly parallel with their slopes, and only the lower rocks of the coal series leaning against their base or rising to a moderate height along their lower acclivities. In quarters where the uplifting movement has been great with a proportionate denudation of the strata along the summit, the top of the mountain is for a considerable space almost flat, and in many instances even hallowed into a double summit by the removal of the soft shales of F. XI. giving prominence to the harder overlying sandstones of F. XII. The latter is especially the case where F. XI. possesses considerable thickness, as it does along Chesnut ridge, especially that southern half of it which bears the name of the West Laurel hill. Where F. XI. is thus developed along each brow of the mountain or immediately over its axis, the reddish iron ore near the top of the formation and the limestone in its lower part, are frequently accessible. These mountain ridges exhibit in their anticlinal axes a beautiful confirmation of that almost invariable law which I have discovered to belong to the axes of elevation, generally, of the whole Appalachian chain of the United States. The feature I allude to, is a greater steepness of the strata on the northwestern than on the southeastern side of the axis.

The coal basin of the Ligonier valley included between Laurel hill and Chesnut ridge maintains a very regular breadth of about six or seven miles throughout its entire length from the Conemaugh to the Youghiogheny river. The coal measures extend entirely across the valley, resting against the base of each mountain and rising a moderate distance up its slope. The inclination of the rocks is generally very gentle, being seldom more than 7°. The only exception to this is along the eastern edge of the valley, or rather in the lower slope of Laurel hill, where the N. W. dip, obedient to the want of symetry in the anticlinal axes above spoken of, is much steeper than elsewhere, amounting in some places, especially near the Youghiogheny, to 30°. In the central tracts the strata are nearly horizontal over a considerable breadth of the valley but being deeply trenched by the valleys of the larger streams their mineral contents are well exposed aud placed accessible to the miner.

Commencing our local details, as far as we shall attempt minute description, with the geology of the basin in the neighborhood of the Conemaugh, let us begin with the stratification in the neighborhood of Armagh and Lockport. The following section, derived from a careful examination of the beds at Lockport, will serve to represent the lower beds of the coal series as they occur, not only there, but at various other localities along the river.

Section at Lockport—Conemaugh river.

Coal, (E,) indicated by its smut and a bench.		
Sandstone, with other overlying strata,	25 feet.	
Coal, (D,)	6 "	
Strata undetermined,	20 "	
Coal, (C,)	2 feet	4 inches.
Strata undetermined,	20 "	
Coal, (B,) of excellent quality,	2 "	
Limestone, 3 feet thick contained in a space of	10 "	
Hydraulic limestone, passing into blue shale,		8 "
Iron ore, 6 to 8 inches,		7 "
Shale, containing scattered iron ore,	12 "	
Iron ore, 4 to 6 inches,		5 "
Shale,	25 "	
Coal, (A,) comprising coal 6 inches, slate 1 foot, coal 2½ feet 4 inches.		
Sandstone.		
Rocks of F. XII., in the river bed below Lockport.		

It will be seen by the following section, procured at Centreville, that none of the lower beds of the previous section are above the levels of the streams at this place, which is near the centre of the basin. We do not pretend to introduce into this and the other accompanying sections all the strata found in the adjacent hills, deeming it best to restrict our list to those which could be definitely ascertained and measured between the water level and the limit of the good exposures, intending to complete the series by an entire section embracing the upper beds derived from explorations nearer Ligonier.

Section at Centreville.

Limestone, (under coal bed E,)	6 feet.
Strata undetermined,	20 "
Coal, (D,)	6 "

This coal lies a little below the bed of the river but appears a quarter of a mile above and a mile and a half below the village, shewing this to be the centre of the basin.

Passing still further across the basin towards its eastern side, the lower beds embraced in the Lockport section again rise from below the water level, as will be seen by a comparison of that with the following section made at Rogers' mill, near Laurel hill:

Section at Rogers's mill.

Coal, (E,)	1 feet	8 inches.
Strata undetermined, a small interval.		
Limestone,	6? “	
Strata undetermined,	20 “	
Coal, (D,) containing at Logan's 2 inches of black slate,	6 “	2 “
Strata undetermined,	20 “	
Coal, (C,) of good quality,	1 “	
Slaty sandstone,	10 “	
Coal, (B,) of good quality,	1 “	8 “

Above the coal E, occur the signs of two other beds, the uppermost being near the tops of the hills.

In the hills at Bolivar, on the western side of the basin, the strata are similar to those at Lockport, the limestone accompanying the coal seam E, being there visible in its usual position. About two miles north of Bolivar, we find the coal bed C, but instead of measuring 2 feet 4 inches, it is here 4 feet thick. The limestone of the bed E, is there likewise 4 feet thick.

East of Armagh, five miles, and one and a half north of the turnpike gate, we again find the 6 feet bed, (D,) occurring at the foot of the mountain. We here meet with indications of no less than seven beds, though only this one appears to be adapted to mining. On Finley's run, the lowest coal bed, A, shows itself and contains 3 feet of good coal. Almost immediately beneath it occur the sandstones F. XII., measuring here about fifty feet, and further down the stream appear the red shales of F. XI. The iron ore, often found near the upper limit of this last formation, was here sought for but not found. Its existence in another locality, on a hill about two miles from the run, is betrayed by a large deposite of bog ore which has been used to supply a small furnace. Guided by this deposite, the hard ore may very probably be found, and should it be present in quantity, it must be traceable to within a few rods of the furnace. The previous sections will suffice to indicate to the proprietors of land in this vicinity in what positions to search for the large coal seam, D, and the limestone above it. The deposite of bog ore, which is near the top of Laurel hill, occupies about four acres of surface, and varies in depth from 4 to 20 feet. At the bottom the ore is concreted and dark while higher up it consists of alternating hard and soft bands. Its average thickness over the four acres may be estimated at 10 feet. Within six feet of the lower edge of the outcrop of F. XII. are indications of the hard ore of F. XI. in a bench traceable for several miles, bog ore springs similar to the previous one being seen along the mountain. The outcrop of the red shale, F. XI., at the passage of the Conemaugh through Chesnut ridge, was carefully examined for ore but without success. Ross furnace, which has been in operation for more than twenty years, has recently been much straitened for ore; as springs depositing bog ore issue from the junction of the red shale and F. XII. it is possible that the hard ore may be discovered here if the clue be properly pursued. The ore bed formerly worked might be mined below its outcrop, as it undoubtedly descends with the western dip of the strata.

From the vicinity of Fairfield to a little north of Ligonier, there is a belt of country along the middle of the basin from 2½ to 3 miles wide which embraces the upper strata, the most productive in coal and limestone of the valley. The limestone is here more abundant than usual. The following section represents the stratification about two miles north of Ligonier:

Section—Ligonier Valley.

Limestone, at the summits of the hills,	7	feet.	
Strata undetermined, about	40	"	
Coal, (L,)	3	"	
Stratum unknown,	5	"	
Limestone, (e,) 6 feet thick at Keiffer's,	4	"	
Coal slate,	10	"	
Coal, (K,)	3	"	
Olive slate and soft brown shale,	20	"	
Coal, (I,) 10 feet at Keiffer's, 7 feet at Giesy's,	8	"	6 inches.
Strata unknown,	20	"	

Limestone, (d,) 4 to 9 feet,	5 feet.
Shale and sandstone,	20 "
Coal, (H,) of good quality,	3 "
Stratum unknown,	8 "
Limestone, ferruginous,	3 "
Brownish olive shale and black slate, not measured, about	15 "
Coal, (G,) smut only seen.	
Sandstone,	50 "
Olive shale,	24 "
Black slate,	6 "
Coal, (F,) not opened.	
Materials unknown, about	15 "
Coal; supposed to be one of the thin bands accompanying F elsewhere.	
Olive shale,—a little iron ore,	30 "
Coal, (E,)	1 "
Limestone, (b,)	1 "

The lowest coal and limestone of this section corresponding to the uppermost coal and limestone of the section at Lockport, we possess in the union of the two a very complete representation of the whole series of beds composing this coal basin. In the Ligonier neighborhood other lower bands were noted which I have not included in the section, as they did not admit of precise admeasurements. One of these is a coal seam 1 foot thick, corresponding probably to the bed C of other localities; another is a coal seam the representative of A, mined by Mr. Mitchell, near the foot of Chesnut ridge, where it is 5½ feet thick. At a short distance beneath this appear the sandstones of F. XII. Both of these coals, with their accompanying rocks, are far below the water level in the immediate neighborhood of Ligonier town, and emerge to the day only on the two sides of the basin.

The large coal seam, I of the section, occurs on many farms along the central part of the valley, having its eastern and western outcrops along the slopes of a range of high narrow hills occupying the middle of the trough. It varies in thickness from 7 to 10 feet. The coal is jet black, of a brilliant lustre, and comparatively free from sulphuret of iron and slate. These features, together with its position in the series, make it probable that this fine bed of coal is identical with the large Pittsburg seam, by far the most valuable member of western coal measures. This coal is of a firm texture, though it affects to a partial extent that columnar form so prevalent in many of the coal beds in the basins near the Allegheny mountain. At Giesy's it is lifted in long columnar pieces, but at Keffar's and other places it does not show this structure.

The seam A, worked by Mr. Mitchell near the foot of Chesnut ridge, after dipping under, emerges on the other side of the valley between Laughlinstown and Laurel Hill, where its outcrop is indicated by a smut immediately above the upper beds of F. XII. It is there overlaid by several other seams occupying the position of the lower beds seen in our previous sections. Thus the first above it, accompanied by a limestone, is probably the bed B, though it is here only a foot and a half thick. Next in the order ascending are two thin adjacent bands, the representatives probably of C, while higher up occurs a bed, the equivalent of D, which is here 3 feet thick, and accompanied by a considerable amount of iron ore. At Ross furnace, in the same belt of strata, but further to the north by six miles, this lowermost bed, A, was recently opened by us, and ascertained to be 4½ feet thick, though it had lain neglected, under an erroneous belief that it was of very insignificant size. Our knowledge of the stratification led us to apprehend an error in the statements given that it was only a foot or so in thickness, while the result has established the accuracy of the comparisons which suggested that this was the coal A, and that it ought to be of dimensions available for mining.

The large coal bed I, has been detected in a few places south of the Conemaugh, but it lies every where too near the tops of the hills to be profitably wrought. It was sought for in a bench near Rogers's mill, on very elevated ground, but the only trace of a coal seam discovered was a thin band five inches thick.

That part of the coal basin which lies between the Loyalhanna and the head waters of Indian creek, is comparatively illy provided with accessible coal seams. This remark applies more expressly to the central tracts of the valley which, in the country north of Ligonier, we have found to be so well supplied. The only productive portions of the district now to be described are the two strips of country bordering the edges of the basin, where the coal beds B, C, and E, of the lower part of the series rise to the surface from beneath the thick superincumbent sandstones and shales which fill the series from E to H, and which here occupy all the middle of the basin. A carefully compiled section, elaborately made from observations in a great variety of places, shows that the only valuable material included within the first or uppermost one hundred and fifty feet of strata in the central hills of the valley is a single band of limestone, about one foot and a half thick, while the only workable coal seam within the space is a high bed, probably H, near the top of a hill in the very middle of the basin. Below this barren group of rocks, but only at the sides of the valley, occur the lower coal seams and a limestone. Thus the coal bed E, the first of these descending, shows itself along the valley of Four Mile run and a little further west, immediately at the base of Chesnut ridge. It is opened at the bridge over the stream, on the Greensburg road, a mile west of Four Mile run, where it is 3 feet 1 inch thick. This bed corresponds in position with that opened by Mr. Nelson, six miles S. S. W. from Ligonier, though the latter bed is only 1 foot 1 inch in thickness. So remarkable a declension in the size of the bed in so short a distance, in this direction, is the only circumstance which suggests any doubt in respect to the identity of the coal of the two places. A band of limestone accompanies the coal at each locality. Indications of a large bed of coarse calcareous iron ore occur in immediate connexion with the limestone at the place mentioned on the Greensburg road.

On Chesnut ridge, near an old furnace on Jacob's creek, three miles S. W. of Harman's, the same coal bed, E, has been opened and shows a thickness exceeding 4 feet. A band of cannel coal, 6 inches thick, traverses the seam about eighteen inches from the roof both here and at the opening just previously mentioned, serving if other evidence were wanting, to identify the bed. Its underlying limestone and attendant iron ore were also found within four or six feet of the coal. The limestone measured 1 foot, and the kidney ore over it amounted to from 2 to 5 inches in total thickness.

The next coal seam descending is C, separated by about forty feet of sandstone from the above described bed E, and thirty-five feet below it again is the well marked stratum B. Each of the beds, B and C, is here 2 feet thick; the separating shales contain a solid band of iron ore of excellent quality, varying in thickness from 5 to 8 inches, besides a considerable amount of ore in detached flattened balls. These things occur at Harman's, up Four Mile run, above the mill which is at the crossing of the Greensburg road. The spot appears to be important on account of the abundance and good quality of the ore, though the immediately adjoining coal beds, B and C, are scarcely of sufficient thickness to be available towards the manufacture of iron at this place, the thicker workable seam E, with its companion the limestone lies higher up in the same hill. A heavy bed of conglomerate, the uppermost of F. XII. underlies the coal B, and iron ore at a very moderate distance, suggesting that the coal A, if indeed it continue in this neighborhood, must lie beneath this rock, as we find it further south. Such alternation of the lower coal seams with the upper beds of F. XII. is of frequent occurrence in all our coal fields, both bituminous and anthracitic.

Eastward from the old furnace of Jacob's creek occur the two coal beds, B and C, with their interposed iron ore. Here they are only twenty feet apart and show a corresponding reduction of thickness, the bed B measuring but one foot, and the bed C one foot and a half. In the interval we find six inches of good iron ore embraced within four feet of shale.

Near the above spot the red shale F. XI. shows its limestone cropping out in a stratum 15 feet in thickness. The iron ore near the top of the formation was formerly procured for the furnace. It lies in several bands whose aggregate thickness is about 8 inches.

The topographical features of the section of the basin we have been describing are somewhat peculiar, owing to the prevalence of soft shales in that portion of the series occupied by the hills of the central belt of the valley. The summits are often quite plane, though gently sloping in conformity with the gentle dip of the strata.

Of the hills in the middle of the basin near the county line dividing Westmoreland and Fayette.

Let us shift our attention now to that part of the valley which borders the dividing line of Westmoreland and Fayette. In the rolling surface of this district we detect many of those indentations in the hills called coal benches, very few of which however have been penetrated for the coal. These hills contain only the middle portion of the coal series or the strata which intervene between the bed B, and the large upper seam I. Hence the relatively small amount of workable coal in this neighborhood. At the base of the hills the coal E and its limestone certainly exist, and perhaps the next inferior bed D, which on the Conemaugh is in some places 6 feet thick, but probably thinner here. These are the only available strata in all the central region between the head waters of Indian creek and the southern branches of the Loyalhanna.

Of the strata on Indian creek.

Passing southward, down the tributaries of Indian creek, we follow it for eight or ten miles through the coal measures, descending in the stratification until we reach Fayette furnace at the mouth of Laurel run, where the stream flows over rocks that may be referred either to the upper part of F. XII. or the lower portion of the coal measures; for coal A, (here one hundred feet beneath the creek,) may be referred as well to the former as to the latter. Continuing down the creek, which enters lower and lower strata in its course, the underlying coal bed A, at length appears about two miles below St. John's furnace, where it is embraced among massive sandstones, that form a series of steps at their outcrop along the channel of the creek, nearly the whole way from a mile above the furnace to the mouth of the stream. We may consider the main body of F. XII. to commence below the coal bed, and to embrace all the rocks thence to near the mouth of the creek where the stream at last reaches the red shales of F. XI. exposing them, in a thickness of fifty feet, resting upon their well marked calcareous sandstone at the water level. As the rocks here dip gently eastward, towards the middle of the basin, we find these beds of F. XI. disappearing below the Youghiogheny as we ascend it in the same direction, the neighboring bluffs showing all the way at their base vast bodies of debris in the form of broken blocks of sandstone and conglomerate, derived from the cliffs above, where F. XII. rises nearly perpendicularly two hundred feet from the stream. Regarding F. XII. as terminating at the first coal seam, A, the total thickness of the formation will be about one hundred and fifty feet; but if we make it to embrace the coal and the over resting conglomerate and sandstone, the whole will measure about two hundred and fifty feet. Ascending the river, F. XI. is out of reach until we get about two miles above the Ohiopile falls; here it emerges with a tolerably steep western dip and is followed, as we approach the gap of the mountain, by the rocks of F. X., and finally, at the axis of the ridge, by those of formation IX.

The sections designed to exhibit the stratification in this region were unavoidably meagre, though data enough were collected to establish an accordance among themselves and between them and the corresponding parts of a more complete section obtained in the neighborhood of Fayette furnace.

In this principal section, (which is represented in the engraved sheet,) the largest coal seam of this part of the valley is the bed B, which near the furnace yields $3\frac{1}{2}$ feet of good coal, and an extra foot of an inferior kind. It has been also exposed at intervals for several hundred feet by the erosive action of the stream along Indian creek just above the mouth of Laurel run; it was once worked at this place by stripping it at its outcrop. At both the above localities it underlies a bed of brown shale. The coal may be seen cropping out in a deep ravine to the west of Indian creek, crossed by the turnpike leading to Connellsville. It was once mined by stripping at St. John's furnace, where its elevation above the stream is about eighty feet.

The limestone accompanying this coal appears where the turnpike crosses Indian creek, in a bed 8 feet thick. About fifteen feet above the coal lies a band of iron ore 8 inches thick.

The coal seam, A, previously stated to be one hundred feet lower in the series was passed in boring a salt well near the furnace. Its thickness in the well has been stated to us at 1 foot, agreeing with its dimensions at its outcrop in the creek's bed, two miles below St. John's furnace. This coal is of excellent quality.

Fifty feet above the coal bed B, lies C, once opened where the turnpike ascends the first hill west of Indian creek, and stated to be 3 feet thick, but of indifferent quality.

About one hundred feet above this, a band of light colored pure limestone has been quarried, the thickness of which could not be ascertained from the falling in of the earth. A bed of coal overlies it within a few feet, yielding it is stated, 3 feet of good coal. Strata deemed to be the same, were met with four miles further south, on Mr. M'Koun's farm, where the coal is in two bands separated by nearly four feet of fire clay, the upper band showing 3 feet of coal, containing no impurity but sulphuret of iron, and the lower band, $1\frac{1}{2}$ foot of equally good quality. A calcareous spring, indicating the outcrop of the limestone, issues about fifteen feet below the outcrop of the coal. About forty feet above the coal bed occurs a bench which suggests the presence of another. Unable to procure any extensive continuous section of the strata in this vicinity, we are in some doubt to what part of the coal measures to refer the first mentioned seam with its limestone, for we may regard it as either B, or E, of the series. Appearances incline us to refer it to the former.

At Lennard's, one mile north of Bear run, appears a band of limestone belonging to the coal bed E, though the coal itself has not yet been seen here. Fifty feet higher in the hill is an outcrop crossing the road which appears to belong to a large bed. Westward of Lennard's, towards the river, two lower coal seams have been opened on a small run; the uppermost, coal B, being 1½ foot thick, and the undermost, one hundred feet further down, being 2 feet thick. No limestone has yet been recognized accompanying the first of these coals.

To return to the section at Fayette furnace, we find from fifty to sixty feet above the coal E, and its limestone, a well marked bench containing probably the highest seam which has resisted the denuding action of the waters in this part of the valley.

On Bear run, three miles north of the Ohiopile falls, and one mile from the river by the course of the run, a coal bed has been opened yielding 3 feet of very pure coal. It overlies a mass of sandstone, this rock constituting the principal material between this level and that of the river below. It was impossible to decide upon the precise position in the series held by this bed, though every thing except the absence of a band of limestone suggests its reference to the seam B. It is regarded as the purest coal in this section of the valley. A very irregular coal seam occurs thirty feet down between the sandstone; it varies from an inch to a foot in thickness, and it probably corresponds with a very irregular bed observed at the Ohiopile falls, and again on Maiden creek; at which latter place it rests beneath twenty feet of sandstone and is 2 feet thick, having the same appearance as if it had been crushed. May not this coal be the irregular commencement of a bed holding an intermediate position between A and B, and which, in other districts, may assume the character of an important and continuous stratum?

Ascending the Youghiogheny from its falls, we come in the distance of about a mile upon the limestone and calcareous sandstone of the lower part of F. XI. The limestone, which varies in quality from a very arenaceous rock to one well adapted to making lime, is at least 30 feet in thickness. Sherman's run exposes the sandstone strata of F. X. throughout nearly its whole course. Formation XII. forms high hills to the west of Sherman's run, its outcrop presenting huge blocks of conglomerate and sandstone. Under this outcrop near the junction of the red shale, F. XI., are to be seen loose pieces of the iron ore so common in this situation. Formation XI. here contains, however, much more sandstone than it shows in the country further to the N. E. In this vicinity, which is at the western base of the broad mountain ridge of Laurel hill, the rocks manifest that steepness of dip so common on the western side of all our great anticlinal axes, the inclination here being as much as 45°.

Signs of coal occur near the head of Bear run, where the hills rise to an elevation of nearly two hundred and fifty feet above the position occupied by F. XII. Near their summits we find a coal smut, indicating a large bed, probably the same with that already noticed as appearing in the road at Lennard's. In F. XII. occurs here a bed of coal 2 feet thick, being either the seam A, or the variable interpolated one before described.

Of the part of the basin south of the Youghiogheny.

That part of the valley embraced between the Youghiogheny and the southern line of the state has yielded us less satisfactory data for a description of its geology than any section further north. The season adapted to field duties being far advanced and the country requiring a leisurely examination to reveal its obscure stratification, little was accomplished beyond what amounts to a reconnaissance to its topography and the identification of a few of its beds.

A seam of coal was formerly opened and mined to a small extent on the first stream which enters the river from the west below Cucumber run. It is 4 feet and a few inches thick, including 5 inches of slate near the top. Lying on the banks of a stream having little fall and in a neighborhood deficient in exposures of the strata, it was impossible to settle its position in the series, though the evidence preponderates which would refer it to one of the lower beds. Did any evidences of limestone accompany it we should regard it as a part of bed B; yet this rock being elsewhere sometimes several feet below its coal it may exist here under the level of the run. Though no other coal bed has been discovered in this neighborhood S. W. of the falls, the great height of the hills and the occurrence of several benches imply the existence of at least four or five seams in all.

Near the middle of the valley and half a mile north of the National road coal occurs in the lowest grounds. Fragments of conglomerate abounding near it induce us to refer it to the bed B, the nearest to F. XII. The seam is 3 feet thick, parted in the middle by an inch of slate; it yields a fuel well adapted to the purposes of the blacksmith. It is worked by stripping only. The strata here are level. About thirty feet above this, in an adjoining hill, is seen the smut of another coal seam, (C?) which corresponds very well in position with the bed at Smythfield in the basin east of the mountain. Another bench, showing black coal slate, (coal D?) appears 25 feet above this. These three are all the coal beds thought to exist in this neighborhood. A fourth of a mile south of the National road and a mile east of the former place a coal bed, (C?) corresponding in character with the Smythfield seam, is worked at its outcrop. The bed contains, first, a layer of coal 2 feet thick, resting on 1 foot of good fire clay, this underlaid by 15 inches of coal which also reposes on good fire clay. The coal, otherwise pure, is somewhat sulphurous. Twenty-five feet above this may be noticed another coal bench, (coal D?)

At Chalk hill on the National road, not far from Stewart's furnace, occurs an indifferent slaty bed of coal, overlaid by a heavy bed of olive shale. It is 1 foot 6 inches thick. A well sunk 50 feet below this coal reached no other bed, nor did it meet the coarse sandstone, F. XII., which crops out within less than a mile west of Chalk hill, towards Chesnut ridge, here erroneously called Laurel hill. Higher up the mountain the calcareous sandstone near the base of F. XI. displays itself, being used as a road stone, for which it is well suited by its toughness.

The lowest seam of coal along the western margin of the basin might, I conceive, be easily detected by following the indications of the rocks exposed along the National turnpike. Its discovery here would prove of some utility.

Of the Coal Measures interposed between F. XI. and F. XII.

In describing the strata in the neighborhood of Turkey foot, in the basin east of Laurel hill, we made mention of a thin group of coal bearing rocks having no connexion with the main body of the coal measures, but holding a position corresponding to the upper layers of F. XI. and the lower rocks of F. XII. These earlier formed carboniferous strata gradually developing themselves in our progress to the S. W., do not show themselves conspicuously in the basin west of Laurel hill until we reach this district south of the Youghiogheny, corresponding to the Turkey foot country on the opposite side of the mountain. Near Stuart's furnace before referred to, these interpolated coal strata contain a seam of excellent coal 4 feet in thickness. It lies entirely below the coarse rocks of F. XII. and twenty feet below the band of iron ore which *usually* marks the common limit of this formation and the red shale, F. XI. The ore here occupies a brown shale, so that it may be considered as appertaining to the coal measures which thus form as it were a subordinate part of the underlying red shale formation. This ore occurs in four separate bands, two of which within three feet of each other are near enough to be worked together. The upper band is less than an inch in thickness, while the lower varies from 1½ to 3 inches. These were the most productive layers known here, until others a little thicker were recently discovered in the same formation north of the National road, and four miles from the furnace. In the new locality the ore is in two adjacent layers, equivalent in all to a thickness of about 8 inches; its quality is very good. The same ore, at the top of the red shale, was formerly worked on the Clay turnpike on Chestnut ridge near Connellsville and is said to have proved abundant and good.

CHAPTER III.

Chemical composition of various Iron Ores, Coals, Limestones and other substances.

Having undertaken an extensive and systematic chemical examination of our *iron ores*, *coals*, *cements*, *limestones*, and other useful minerals, with a view to settle precisely the composition and properties of each, I propose to pursue here the plan adopted in my last annual report, and submit the results of a number of the analyses made during the past year by my assistants, Dr. R. E. Rogers, Martin H. Boye, and Professor James B. Rogers.

The limited scope of an annual report, and the yet unfinished state of some of our chemical researches which need much care and time in the experiments, induce me to postpone to the pages of my final report various conclusions and discussions of a practical character, suggested by the analytical details now presented. In the mean while, however, it will interest all who are directly or indirectly concerned in developing or using any of the mineral treasures of the State, to find in the following pages the true composition of a number of our ores, coals and limestones, including in the latter several varieties employed as fluxes and hydraulic cements.

I shall classify the analyses according to the geological order of the formations in which the different minerals occur, adopting as in all my descriptions the ascending order.

SECTION I.

ANALYSES OF ORES,

I. *Analyses of Iron Ores from the primary formation.*

MAGNETIC IRON ORE from Trine and Fegely's mine, three miles S. E. from Metztown, Berks county. This ore occurs as a vein in gneiss.

Description.—Color dull iron black, imperfectly crystallized in dodecahedrons; lustre splendent; possesses magnetic polarity.

Composition in 100 parts:

Magnetic oxide of iron,	88.92
Alumina,	a trace
Silica,	10.60
Water,	0.20
Loss,	0.28
	100.00

This specimen contains 65.52 per cent. metallic iron.

MAGNETIC OXIDE OF IRON from one mile S. E. of Hellerstown, Lehigh county.

Description.—Color iron black; structure somewhat laminated, presenting imperfect rhombic crystalline faces; lustre semi-metallic; possesses magnetic polarity.

Composition in 100 parts:

Magnetic oxide of iron,	85.50
Alumina	trace
Silica,	12.60
Water,	1.25
Loss,	0.65
	100.00

This specimen contains 63.00 per cent. metallic iron.

II. *Analysis of Iron Ores of Formation, II. & III.*

Iron Ore from Hartman's field, Northampton county.

Description.—Structure porous, cellular; texture soft and crumbly; color, bright chesnut brown.

Composition in 100 *parts:*

Per oxide of iron,	65.60
Alumina,	1.00
Silica and insoluble matter,	17.82
Water,	14.98
Loss,	0.60
	100.00

The metallic iron amounts to 45.92 per cent.

Iron Ore from Albright's new mine, near the church south of Trexlerstown, Lehigh county.

Description.—Red hematite; structure distinctly fibrous, concretionary and stalactitic; color brownish red, with bluish grey points on the surface; lustre considerable.

Composition in 100 *parts:*

Per oxide of iron,	82.00
Alumina,	a trace
Silica and insoluble matter,	5.32
Water,	12.25
Loss,	0.43
	100.00

This specimen contains 57.40 per cent. metallic iron.

Iron Ore from Jacob Rice's, five miles N. W. of Bethlehem, Lehigh county. Shell ore thirty feet from surface.

Description.—Structure, porous cellular, quite brittle; color, rich chesnut brown.

Composition in 100 parts:

Per oxide of iron,	70.25
Alumina,	1.55
Oxide of manganese,	a trace
Silica and insoluble matter,	16.40
Water,	11.40
Loss,	0.40
	100.00

This specimen contains 49.17 per cent. metallic iron.

Iron Ore from Jacob Rice's, same locality as above, found from forty to fifty feet from surface. It is a pipe ore.

Description.—Structure pipes, closely adhering, compact brittle; color chesnut brown; surface stained red from adhering red oxide.

Composition in 100 parts:

Per oxide of iron,	79.12
Alumina,	1.56
Silica and insoluble matter,	4.80
Water	13.98
Loss,	0.54
	100.00

This specimen contains 55.38 metallic iron.

Iron Ore from Brotzman's, Northampton county.

Description.—Amorphous, and somewhat mammillary; color brown, in some places mottled with white specks of clayey or siliceous matter, in others dark brown and shining. Average of the mass taken for analysis.

Composition in 100 parts:

Per oxide of iron,	71.72
Per oxide of manganese,	0.70
Silica and insoluble matter,	16.55
Water,	11.03
	000.00

This specimen contains 49.78 per cent. metallic iron.

IRON ORE from Dillinger's farm, one mile S. E. of Hellerstown.

Description.—Brown hematite; compact, interspersed with veins of shining fibrous hematite; color, brown.

Composition in 100 parts:

Per oxide of iron,	85.71
Oxide of manganese,	1.05
Alumina,	a trace
Silica and insoluble matter,	1.50
Water,	11.74
	100.00

This specimen contains 59.42 per cent. metallic iron.

IRON ORE from Richards's, Lehigh county.

Description.—Structure somewhat nodular, amorphous; color brown throughout the map, coated externally with a yellow clay, in some parts blue. Average of the whole selected for analysis.

Composition in 100 parts:

Per oxide of iron,	71.72
Oxide of Manganese,	10.42
Alumina,	a trace
Silica and insoluble matter,	4.12
Water,	13.21
Loss,	0.53
	100.00

This specimen contains 49.72 per cent. metallic iron.

IRON ORE from Moyer's, four miles N. N. W. from Allentown, Lehigh county, called lump ore.

Description.—Structure compact massive; color dark chesnut brown.

Composition in 100 parts:

Per oxide of iron,	72.17
Alumina,	1.50
Oxide of manganese,	trace
Silica and insoluble matter,	12.30
Water,	14.00
Loss,	0.03
	100.00

This specimen contains 50.51 per cent. metallic iron.

Iron Ore from same locality as above. Pipe ore.

Description.—Structure irregularly stalactitic; pipes close adhering; color rich chesnut brown.

Composition in 100 parts:

Per oxide of iron,	79.21
Alumina,	0.75
Manganese,	none
Silica and insoluble matter,	7.50
Water,	11.00
Loss,	0.54
	100.00

This specimen contains 55.44 per cent. metallic iron.

Iron Ore from Henry Goetz's, five miles N. N. W. from Bethlehem, Lehigh county, called hard ore.

Description.—Massive, compact; fracture conchoidal; color dull black brown; surface lustrous, iridescent and resinous.

Composition in 100 parts:

Per oxide of iron,	84.00
Alumina,	a trace
Silica and insoluble matter,	4.10
Water,	11.60
Loss,	0.30
	100.00

This specimen contains 58.80 metallic iron.

Iron Ore from J. Isaac Breinig's farm, one mile N. W. from Breinigsville, Lehigh county.

***Description.*—Structure massive, quite compact, and close grained; color blackish brown; surface coated with a velvet-like oxide.**

Composition in 100 parts:

Per oxide of iron, - - - - -	75.54
Alumina, - - - - - - -	a trace
Silica and insoluble matter, - - -	11.90
Water, - - - - - - - -	12.15
Loss - - - - - - - -	0.41
	100.00

This specimen contains 52.87 per cent. metallic iron.

Iron Ore from Xanders's Lehigh county.

Description.—Cellular, porous, brittle; color chesnut brown, interspersed with bright reddish yellow spots.

Composition in 100 parts:

Per oxide of iron, - - - - -	77.23
Alumina, - - - - - - -	2.75
Lime, - - - - - - - -	a trace
Manganese, - - - - - - -	a trace
Silica and insoluble matter, - - -	5.80
Water, - - - - - - - -	13.92
Loss, - - - - - - - -	0.30
	100.00

This specimen contains 54.06 per cent. metallic iron.

Iron Ore from bank of Hall and Rowle, three-fourths of a mile S. E. of Greenwood, Kishacoquillas valley, Mifflin county.

Description.—Hard, granular, porous; grains round, internally compact; color brown, with lighter colored interstitial deposit.

Composition in 100 parts:

Per oxide of iron, - - - - - -	82.88
Alumina, - - - - - - - -	0.53
Silica and insoluble matter - - - - -	4.21
Water, - - - - - - - - -	12.38
	100.00

This specimen contains 57.47 per cent. metallic iron.

Iron Ore from Pennington bank, two and a half miles S. W. of Warrior-marktown, Huntingdon county.

Description.—Structure in some parts compact, in others cellular, cells lined with red oxide; color chesnut brown.

Composition in 100 parts:

Per oxide of iron, - - - - - -	76.50
Alumina, - - - - - - - -	none
Oxide of manganese, - - - - - -	2.70
Silica and insoluble matter, - -	7.50
Water, - - - - - - - -	12.50
Loss, - - - - - - - -	0.80
	100.00

This specimen contains 52.50 per-cent. iron.

Iron Ore from three-fourths of a mile N. E. of Pennsylvania furnace, old Pennington bank, Huntingdon county.

Description.—Texture compact, close grained; structure somewhat columnar; color rich brown.

Composition in 100 parts:

Per oxide of iron, - - - - - -	84.80
Alumina, - - - - - - - -	1.50
Insoluble matter, - - - - - - -	3.00
Water, - - - - - - - - -	10.00
Loss, - - - - - - - - -	0.70
	100.00

Per cent. metallic iron 59.36.

Iron Ore from Pond bank, Pennsylvania furnace, new digging, Huntingdon County.

Description.—Structure slender pipes, closely adhering, brittle; color rich brown.

Composition in 100 parts:

Per oxide of iron,	76.50
Alumina,	2.55
Insoluble matter,	11.40
Water,	9.10
Loss,	0.45
	100.00

Per cent. metallic iron 53.55.

Iron Ore from Green Village bank, Caledonia Furnace, Franklin county.

Description.—Structure pipes, quite compacted; color chesnut brown.

Composition in 100 parts:

Per oxide iron,	76.00
Alumina,	2.25
Insoluble matter,	11.00
Water,	10.25
Loss,	0.50
	100.00

This specimen contains 52.20 per cent. metallic iron.

Iron Ore from Formation III. Hanover furnace ore bank, Lowrey's knob, Bedford county.

Description.—Brittle, granular, in some parts of a brick red color, in others opalescent, argillaceous.

Composition in 100 *parts:*

Per oxide of iron,	36.71
Alumina,	14.46
Insoluble matter,	32.36
Manganese,	a trace.
Water,	16.47
	100.00

Per cent metallic iron 25.45.

II. *Analyses of Iron Ores from Formation V.*

Iron Ore from synclinal axis of Little Cove, Franklin county.

Description.—Color dark red and brown; granular, including in some portions pieces of imbedded quartz, and in others numerous grains of sand, presenting the appearance of a coarse sandstone, with ferruginous cement, the latter preponderating.

Composition in 100 *parts:*

Per oxide of iron,	30.38
Alumina,	1.20
Silica and insoluble matter,	67.00
Water,	1.42
	100.00

This specimen contains 21.06 per cent. metallic iron.

Iron Ore from Mifflin, Juniata county.

Description.—Structure coarse slaty granular; somewhat micaceous, and fossiliferous; color chesnut brown.

Composition in 100 *parts:*

Per oxide of iron,	70.00
Alumina,	a trace.
Silica and insoluble matter,	24.24
Oxide manganese,	a trace.
Water,	5.40
Loss,	0.40
	100.00

RON ORES from Danville, Columbia county, fossiliferous; two varieties, one siliceous and the other calcareous

Description: Calcareous variety.—Structure somewhat slaty; micaceous, fossiliferous; lustre glimmering; color dark bluish rown.

Composition in 100 parts:

Per oxide of iron, - - - - - -	30.34
Oxide manganese, - - - - - -	a trace.
Carbonate of lime, - - - - - -	62.43
Carbonate of magnesia, - - - - -	2.79
Silica and insoluble matter, - - - -	2.64
Water, - - - - - - - -	1.80
	100.00

Per cent. of metallic iron 21.03.

Description: Siliceous variety.—Structure massive, occuring in plates of variable thickness, resembling slabby red sandstone; color brick red, somewhat fossiliferous, not micaceous, and free from lustre.

Composition in 100 parts:

Per oxide of iron, - - - - - -	70.63
Alumina, - - - - - - -	0.57
Carbonate of lime, - - - - - -	2.46
Silica and insoluble matter, - - -	23.77
Water, - - - - - - - -	2.57
	100.00

Per cent metallic iron 48.97.

IRON ORE from Smith's Gap, Blue mountain, Dauphin county.

Description.—Massive, rounded at the edges, coarse grained, apparently composed of small masses of coarser ore imbedded in a paste of brown hematite; color mottled, dark brown.

Composition in 100 *parts:*

Per oxide of iron, - - - - -	68.00
Alumina, - - - - - - -	6.60
Silica and insoluble matter, - - -	13.30
Water, - - - - - - - -	11.70
Loss, - - - - - - - - -	0.40
	100.00

This specimen contains 47.06 per cent. metallic iron.

IRON ORE from two miles south of Landisburg, top of ridge, ar ticlinal axis, Perry county.

Description.—Structure somewhat slaty, brittle, micaceous, highl fossiliferous; color dull brown, with glimmering lustre.

Composition in 100 *parts:*

Per oxide of iron, - - - - - -	76.45
Oxide of manganese, - - - - -	1.50
Alumina, - - - - - - - -	1.25
Silica and insoluble matter, - - -	14.40
Water, - - - - - - - -	5.70
Loss, - - - - - - - - -	0.70
	100.00

This specimen contains 53.51 per cent. metallic iron.

IRON ORE from Turtle creek, west branch of the Susquehanna, Uni county.

Description.—Compact, coarse, siliceous; color pink; resembl the hard ore of Danville.

Composition in 100 *parts:*

Per oxide of iron, - - - - - -	37.64
Alumina, - - - - - - - -	trace
Insoluble matter, - - - - - -	59.00
Water, - - - - - - - - -	3.20
Loss, - - - - - - - - -	0.16
	100.00

Per cent. metallic iron 26 32.

III. *Analyses of Iron Ores of Formation VI.*

Iron Ore from Tuckahoe, Huntingdon county.

Description.—Structure cellular, cells large and angular, and lined with a bluish coating; close grained, hard and brittle; color dull brick red.

Composition in 100 parts:

Per oxide of iron,	71.50
Alumina,	2.50
Oxide of Manganese,	a trace
Silica and insoluble matter,	20.40
Water,	5.00
Loss,	0.60
	100.00

This specimen contains 50.00 per cent. metallic iron.

Iron Ore from same locality as above, Allegheny furnace ore bank.

Description.—Cellular, walls of cells compact and lined with a pulverulent oxide; color light brownish yellow.

Composition in 100 parts:

Per oxide of iron,	69.80
Oxide of manganese,	a trace
Alumina,	2.30
Silica and insoluble matter,	18.40
Water,	8.70
Loss,	0.80
	100.00

This specimen contains 48.86 per cent. metallic iron.

IV. *Analyses of Iron Ores of Formation VIII.*

Iron Ore, Bog ore, from base of Warrior's ridge, Woodcock valley, lower part of the formation.

Description.—Structure massive, texture brittle and earthly; color dull ochreous brown; vegetable fibres, interspersed through the map.

Composition in 100 *parts:*

Per oxide of iron,	75.22
Alumina,	2.50
Silica and insoluble matter,	7.75
Oxide of manganese,	trace
Organic matter,	2.80
Water,	11.45
Loss,	0.28
	100.00

This ore contains 52.65 per cent. metallic iron.

IRON ORE from six miles west of Pinegrove.

Description.—Structure somewhat slaty, porous, cellular, fossiliferous; color mottled brown and drab.

Composition in 100 *parts:*

Per oxide of iron,	37.00
Alumina,	4.20
Carbonate of lime,	1.50
Silica and insoluble matter,	45.90
Water,	11.25
Loss,	0.15
	100.00

This specimen contains only 25.90 per cent. metallic iron.

IRON ORE from Chester ridge, three-fourths of a mile west of Chester furnace, Huntingdon county.

Description.—Compact, easily broken; color variegated brown black; easily scratched by the nail.

Composition in 100 *parts:*

Per oxide of iron,	66.92
Per oxide of manganese,	14.64
Alumina,	1.93
Insoluble matter,	7.57
Water,	9.48
	100.00

Per cent. metallic iron, 46.40. This ore is from the upper part of Formation VII.

IRON ORE from upper part Formation VIII. near its contact with IX., Lycomingcreek.

Description.—Granular, with a structure tending to laminated, shining, fossiliferous; color chocolate brown, powder red.

Composition in 100 parts:

Per oxide of iron,	48.80
Alumina, Oxide of manganese, Lime,	a trace.
Silica and insoluble matter,	49.38
Water,	1.68
Loss,	0.14
	100.00

This specimen contains 33.83 per cent metallic iron.

IRON ORE from two miles west of Pinegrove.

Description.—Structure slaty, porous, cellular, fossiliferous; color dull earthy brown.

Composition in 100 parts:

Per oxide of iron,	32.00
Alumina,	0.50
Lime,	1.00
Silica and insoluble matter,	60.00
Water,	6.00
Loss,	0.50
	100.00

This specimen contains only 22.40 per cent metallic iron.

V. *Analyses of Iron Ores of Formation XI.*

IRON ORE from Bennett's branch of Sinnemahoning, one and a half miles above Warner's, Clearfield county.

Description.—Structure compact close grained; fracture conchoidal; color dull grey; surface ochreous.

Composition in 100 parts:

Carbonate of iron,	82.20
Per oxide of iron,	6.50
Alumina,	1.00
Silica and insoluble matter,	6.65
Water,	3.40
Loss,	0 25
	100.00

This specimen contains of metallic iron 44.22 per cent.

Iron Ore from same locality as above:

Description.—Structure, less compact and coarser than the above; fracture semi-crystalline, somewhat nodular; color grey.

Composition in 100 parts:

Carbonate of iron,	63.80
Alumina,	0.75
Oxide of manganese,	1.00
Silica,	30.90
Water,	2,75
Loss,	0.80
	100.00

This specimen, contains 30.28 per cent. metallic iron.

Bog Iron Ore from hard ores of XI., three or four miles W. of top of Allegheny mountain, near head of East fork of west branch of Muddy river, Cambria and Clearfield line.

Description.—Structure amorphous, cellular, brittle, somewhat earthy; color rich brown; contains veins of brown hematite.

Composition in 100 parts:

Per oxide of iron,	75.15
Alumina,	0.90
Oxide of manganese,	4.00
Organic matter,	0.40
Silica and insoluble matter,	3.40
Water,	16.20
	100.00

This specimen contains 52.60 per cent. metallic iron.

Iron Ore from head of Garey's run, Fayette county.

Description.—Structure nodular and concentric, internally close grained, and of a light dove color, externally somewhat hematitic; color chesnut brown, exhibiting on the surface innumerable iridescent spots.

Composition in 100 *parts:*

Carbonate of iron,	84.14
Per oxide of iron,	2.78
Carbonate of lime,	3.00
Alumina,	0.75
Manganese,	a trace
Water,	5.00
Silica and insoluble matter,	6.50
	000.00

This specimen contains 40.62 per cent. of metallic iron.

Iron Ore from Garey's run, Fayette county.

Description.—Structure kidney shaped, texture of the interior unweathered, portion close grained and compact; color greyish blue; fracture smooth, slightly conchoidal.

Composition in 100 *parts:*

Carbonate of iron,	75.50
Carbonate of lime,	2.50
Carbonate of magnesia,	1.35
Alumina,	2.80
Silica and insoluble matter,	15.55
Water,	2.00
Loss,	0.30
	100.00

This specimen contains 38.22 per cent. of metallic iron.

Iron Ore, Lavages' diggings, Trough creek, Huntingdon county.

Description.—Ore compact, jaspery; color redish brown; fracture conchoidal.

Composition in 100 parts:

Per oxide of iron,	88.9
Alumina,	none
Silica and insoluble matter,	a mere trace
Water,	11.0
Loss,	0.1
	100.00

This specimen contains 69.93 per cent. metallic iron.

Iron Ore from S. E. of Blairsville, Indiana co., on the Conemaugh.

Description.—Nodular, somewhat spathose, apparently composed of a congeries of irregular materials, presenting a mottled green and red appearance.

Composition in 100 parts:

Carbonate of iron,	37.80
Carbonate of lime,	5.50
Carbonate of magnesia,	7.50
Alumina,	7,60
Silica and insoluble matter,	37.80
Water,	3.50
Loss,	0,30
	100,00

Metallic iron 18.27 per cent.

Iron Ore from Christopher Hill's, west side of Chesnut ridge, Indiana county.

Description.—In lenticular shaped masses, compact; color of map cinnamon brown; surface coated with argillaceous crust.

Composition in 100 parts:

Per oxide of iron,	51.25
Alumina,	5.96
Carbonate of lime,	2.00
Ox. of Manganese,	a trace,
Silica and insoluble matter,	36.50
Water,	4 00
Loss,	0.19
	100.00

This specimen contains 35.87 per cent. metallic iron.

IRON ORE from the head waters of Brodhead's creek, Monroe county.

Description.—Structure slaty, coarse grained, and siliceous; color grey, surface covered with a brown ferruginous crust.

Composition in 100 *parts:*

Carbonate of iron,	12.43
Per oxide of iron,	3.43
Alumina,	1.50
Carbonate of lime,	4.00
Oxide of Manganese,	2.20
Silica and insoluble matter,	72.20
Water,	4.00
Loss,	0.24
	100.00

This specimen contains 8.26 per cent. of metallic iron.

IRON ORE from the west side of Chesnut ridge, on the Pennsylvania canal, Westmoreland county.

Description.—Structure compact, close grained; fracture somewhat conchoidal and jaspery; color purple brown, with a tinge of green.

Composition in 100 *parts:*

Per oxide iron,	61.50
Alumina,	1.25
Lime and magnesia,	traces
Silica and insoluble matter,	31.44
Water,	5.20
Loss,	0.61
	100.00

This specimen contains 43.05 per cent. metallic iron.

IRON ORE from Hare's valley, Huntingdon county.

Description.—Massive, micaceous, soft, unctuous, flat, and somewhat laminated; color purplish red.

Composition in 100 *parts:*

Per oxide of iron,	97.54
Alumina,	0.18
Insoluble matter,	3.12
	100.00

Per cent. metallic iron 67.63.

VI. *Analyses of Iron Ores of Formation XIII.*

Iron Ore, argillaceous carbonate, from the St. Clair tract, Pottsville, Schuylkill county.

Description.—Structure nodular, concentric, rather compact; color internally slate blue, externally dirty brown. Average of the whole taken for analysis.

Composition in 100 parts:

Carbonate of iron,	42.38
Carbonate of Manganese,	3.64
Per oxide of iron,	21.32
Alumina,	a trace
Silica and insoluble matter,	27.63
Water,	5.03
	100.00

Per cent. metallic iron 34.86.

Iron Ore from the same locality as above.

Description.—Structure somewhat nodular, compact; color slate blue.

Composition in 100 parts:

Carbonate of iron,	66.67
Per oxide of iron,	2.55
Carbonate of manganese and magnesia,	traces
Carbonate of lime,	8.25
Alumina,	2.25
Silica and insoluble matter,	13.90
Water,	6.10
Loss,	0.28
	100.00

This specimen contains 33.96. per cent. metallic iron.

IRON ORE, Mount Laffy mine, Pottsville.

Description.—Structure nodular, massive, compact; color slate brown; feel meagre; in parts unctuous.

Composition in 100 *parts:*

Carbonate of iron,	39.54
Per oxide of iron,	14.57
Carbonate of manganese,	0.50
Lime and magnesia,	traces
Alumina,	0.50
Silica and insoluble matter,	40.00
Water,	4.60
Loss,	0.29
	100.00

This specimen contains 32.52 per cent. metallic iron.

IRON ORE from same locality as above, Pottsville.

Description.—Structure nodular, compact; slate blue; minute crystals of yellow iron pyrites are disseminated through the mass.

Composition in 100 *parts:*

Carbonate of iron,	45.50
Carbonate of manganese,	1.00
Carbonate of magnesia,	7.50
Carbonate of lime,	6.00
Silica and insoluble matter,	30.00
Bi sulphuret of iron,	0.60
Water,	7.00
Alumina,	2.25
Loss,	0.15
	100.00

This specimen contains 22.05 per cent. metallic iron.

IRON ORE from another bed at the same locality, Mt. Laffy, Pottsville.

Description.—Structure flattened, nodular; texture moderately close grained; color brown, slaty; feel, slightly unctuous.

Composition in 100 *parts:*

Carbonate of iron,	39.54
Per oxide of iron,	14.57
Lime and magnesia,	traces
Carbonate manganese,	0.50
Alumina,	0.50
Water,	4.50
Loss,	0.39
Silica and insoluble matter,	40.00
	100,00

This specimen contains 32.52 per cent. metallic iron.

IRON ORE from Zachariah's run, Pottsville.

Description.—Structure laminated, slaty, micaceous, crystalline, quartz running at right angles to the laminae; color slate blue; surface coated with a thin crust of brown oxide, and presenting a glazed appearance.

Composition in 100 *parts:*

Carbonate of iron,	31.07
Per oxide of iron,	14.37
Carbonate of manganese,	1.25
Carbonate of magnesia,	2.20
Alumina,	1.00
Silica and insoluble matter,	44.80
Water,	5.00
Loss,	0.31
	100.00

This specimen contains 25.05 pet cent. metallic iron.

IRON ORE from the same locality, Zachariah's run.

Description.—Structure nodular, somewhat slaty, compact; color dark blue, but non-decomposed on the outside than the preceding, the ferruginous crust being more considerable.

Composition in 100 *parts:*

Carbonate of iron,	35.13
Per oxide of iron,	28.10
Carbonate of manganese,	2.39
Carbonate of lime,	0.92
Carbonate of magnesia,	8.79
Alumina,	0.91
Silica and insoluble matter,	21.62
	100.00

This specimen contains 41.88 per cent. metallic iron.

IRON ORE from Guinea hill. Pottsville.

Description.—Nodular, concentric, internally hard, externally friable; color of surface dirty brown, of interior slate blue; earthy and meagre to the touch. Average of the whole taken for analysis.

Composition in 100 *parts:*

Carbonate of iron,	31.53
Per oxide of iron,	31.31
Alumina,	a trace
Manganese,	a trace
Silica and insoluble matter,	31.08
Water,	6.06
Loss,	.02
	100.00

This specimen contains 37.14 per cent. metallic iron.

IRON ORE from York farm, Rabbit hole vein, near Pottsville.

Description.—Compact; color dull bluish black, like a dark colored limestone.

Composition in 100 parts:

Carbonate of iron,	48.33
Per oxide of iron,	15.06
Carbonate of manganese,	2.03
Carbonate of magnesia,	5.11
Carbonate of lime,	3.11
Alumina,	1.28
Carbonaceous matter,	1.81
Silica and insoluble matter,	20.25
Water,	3.02
	100.00

This specimen contains 33.35 per cent. metallic iron.

IRON ORE from Port Carbon, Schuylkill county.

Description.—Structure thin, laminated, rather friable; clay interposed between the laminae; small grains of per oxide of iron interspersed through the mass; color dull brown.

Composition in 100 parts:

Per oxide of iron,	53.56
Oxide of manganese,	1.08
Alumina,	trace
Silica and insoluble matter,	36.01
Water,	9.35
	100.00

Per cent. of metallic iron 37.14.

IRON ORE from the Summit mine of the Lehigh, Northampton county.

Description.—Compact, nodular; fracture conchoidal; color slate blue; weathered surface rusty.

Composition in 100 parts:

Per oxide of iron,	21.40
Alumina,	18.60
Lime and magnesia,	traces
Water,	4.00
Carbonic acid,	traces
Silica and insoluble matter,	55.65
Loss,	0.35
	100.00

Per cent. metallic iron 14.98. This ore would gain 4 per cent. by roasting. Though carefully selected with a view to exhibit an average of the ore in the bed, we may perhaps have chosen a specimen a little too poor.

IRON ORE from near Brighton, Beaver county.

Description.—Structure, concretionary; when broken, the outer crust is of a dull red color, the interior crystalline, translucent and grey. The interior undecomposed portion selected for analysis.

Composition in 100 parts:

Carbonate of iron,	43.89
Carbonate of manganese,	7.20
Carbonate of lime,	42.51
Carbonate of magnesia,	3.57
Insoluble matter,	0.40
Water,	2.43
	100.00

This specimen is a highly calcareous ore, and would be rendered much richer by roasting. It contains 20.79 per cent. metallic iron.

IRON ORE from Robinson's farm, near Georgetown, Mercer county.

Description.—Compact; color dark blue; under the microscope exhibits innumerable, shining, crystalline points.

Composition in 100 *parts:*

Carbonate of iron,	84.24
Carbonate of manganese,	1.38
Carbonate of lime,	4.38
Alumina,	0.89
Silica and insoluble matter,	7.00
Water and some carbonaceous matter,	2.10
Sulphur,	a trace
	100.00

This specimen contains 39.93 per cent. metallic iron.

Iron Ore from Mount Eagle, Black Spring gap, Dauphin county.

Description.—Structure slaty, with rhomboidal fracture; color dull, nearly black.

Composition in 100 *parts:*

Carbonate of iron,	73.94
Per oxide of iron,	10.36
Carbonate of manganese,	2.95
Carbonate of magnesia,	2.07
Water,	1.99
Carbonaceous matter,	1.54
Silica and insoluble matter,	6.63
Loss,	0.52
	100.00

This specimen contains 42.22 per cent. metallic iron.

Iron Ore from half a mile west of Lockport, Westmoreland county.

Description.—Compact, close grained, somewhat crystalline in portions, sparry; fracture slightly conchoidal; color slate blue.

Composition in 100 parts:

Carbonate of iron,	45.30
Carbonate of lime,	32.00
Carbonate of magnesia,	4.50
Carbonate of manganese,	2.30
Alumina,	1.25
Water,	6.00
Silica and insoluble matter,	9.45
Loss,	0.30
	100.00

This specimen contains 21.86 per cent. metallic iron; it would gain considerably in richness by roasting, being chiefly a carbonate of iron and carbonate of lime.

Iron Ore from upper stratum, 8 to 9 inches thick, Lockport, Westmoreland county.

Description.—Nodular, close grained; fracture conchoidal; dove color.

Composition in 100 parts:

Carbonate of iron,	69.00
Carbonate of lime,	7.80
Carbonate of magnesia,	a trace
Alumina,	a trace
Silica and insoluble matter,	20.44
Water,	2.40
Loss,	0.36
	100.00

This ore contains 33.32 per cent. metallic iron.

Iron Ore from Lockport, Westmoreland county. Bog ore.

Description.—Texture porous, friable; rich ochre brown, internally chesnut brown; includes delicate vegetable fibres.

Composition in 100 *parts:*

Per oxide of iron,	77.00
Oxide of manganese,	4.50
Alumina,	0.50
Organic matter,	1.22
Water,	12.00
Silica and insoluble matter,	4.00
Loss,	0.28
	100.00

This specimen contains 53,90 per cent. metallic iron.

Iron Ore from first band of Warner's, Iron Run, Bennett's branch, Clearfield county.

Description.—Structure distinctly oolitic, grains small; color light grey, mottled brown, and somewhat glimmering. Interior of specimen taken for analysis.

Composition in 100 *parts:*

Carbonate of iron,	55.82
Carbonate of lime,	5.00
Alumina,	a trace
Silica and insoluble matter,	36.80
Water,	2.00
Loss,	0.38
	100.00

This specimen contains 26.95 per cent. metallic iron.

Iron Ore from the same locality, but higher up Warner's, Bennett's branch of the Sinnemahoning, Clearfield county.

Description.—Structure nodular, concentric; aspect earthy; color dull blue; surface ochreous.

Composition in 100 parts:

Carbonate of iron,	73.81
Per oxide of iron,	4.24
Alumina,	1.00
Lime and manganese,	traces
Organic matter,	0.50
Water,	5.59
Silica and insoluble matter,	14.46

This specimen contains 38.59 per cent. metallic iron.

IRON ORE from Canal, one mile above Blairsville, Westmoreland county.

Description.—Compact, coarse grained, semi-crystalline; color bluish grey.

Composition in 100 parts:

Carbonate of iron,	71.19
Carbonate of lime,	3.50
Carbonate of magnesia,	2.72
Alumina,	2.10
Silica and insoluble matter,	17.55
Water,	2.70
Loss,	0.24
	100.00

Per cent. of metallic iron 34.37.

IRON ORE from same locality as above; different variety.

Description.—Structure nodular, fracture conchoidal, compact; dove colored, surface ochreous and smooth.

Composition in 100 parts:

Carbonate of iron,	67.20
Per oxide of iron,	7.48
Carbonate of lime,	3.24
Carbonate of magnesia,	1.50
Alumina,	a trace.
Water,	8.00
Silica and insoluble matter,	12.34
Loss,	0.24
	100.00

Per cent metallic iron 37.24.

IRON ORE from Limestone run, above limestone stratum, on Warner's, Bennett's branch of the Sinnemahoning, Clearfield county.

Description.—Structure flat, kidney shaped masses, concentric; somewhat crystalline; color blue grey.

Composition in 100 parts:

Carbonate of iron, - - - - - -	55.10
Per oxide of iron, - - - - - -	9.50
Alumina, - - - - - - - -	2.10
Carbonate of lime, - - - - - -	5.80
Carbonate of magnesia, - - - -	5.40
Silica and insoluble matter, - - -	18.90
Water, - - - - - - - -	3.00
Loss, - - - - - - - - -	0.20
	100.00

Per cent. metallic iron 34.72.

IRON ORES from Shamokin Coal Company's lands, four different varieties.

Description.—First variety: Compact, close grained, hard; fracture somewhat slaty; color dark blue; surface rusty.

Composition in 100 parts:

Carbonate of iron, - - - - - -	56.90
Per oxide of iron, - - - - - -	24.90
Alumina, - - - - - - - -	1.00
Lime and manganese, - - - - -	traces
Silica and insoluble matter, - - - -	16.05
Water, - - - - - - - -	1.50
Loss, - - - - - - - - -	0.15
	100.00

Per cent. metallic iron, 44.87.

Description.—Second variety: Massive, close grained; fracture somewhat conchoidal; surface glazed; color dull bluish black.

Composition in 100 parts:

Carbonate of iron,	74.50
Carbonate of lime,	5.40
Carbonate of magnesia,	a trace
Corbonate of manganese,	a trace
Alumina,	2.80
Silica and insoluble matter,	14.30
Water,	2.50
Loss,	0.50
	100.00

This specimen contains of metallic iron 35.98 per cent.

Description.—Third variety: Nodular, coarse grained, a little crystalline; color blue grey.

Composition in 100 parts:

Carbonate of iron,	63.20
Carbonate of lime,	1.00
Carbonate of magnesia,	a trace
Alumina,	1.50
Silica and insoluble matter,	31.15
Water,	2.50
Loss,	0.65
	100.00

Metallic iron 30.52 per cent.

Description.—Fourth variety: Kidney ore; nodular, flattened masses; texture compact; surface rusty, internally slate blue.

Composition in 100 parts:

Carbonate of iron,	58.00
Per oxide of iron,	8.45
Carbonate of lime,	a trace
Carbonate of magnesia,	a trace
Carbonate of manganese,	4.50
Alumina,	4.50
Organic matter,	1.50
Silica and insoluble matter,	15.44
Water,	7.50
Loss,	0.11
	100.00

Per cent metallic iron 45.92.

IRON ORE from mountain near Shamokin Iron Works.

Description.—Structure porous, cellular, brittle; color rich light chesnut brown.

Composition in 100 parts:

Per oxide of iron,	79.50
Alumina,	a trace
Oxide manganese,	a trace
Organic matter,	2.50
Water,	12.50
Silica and insoluble matter,	4.80
Loss,	0.70
	100.00

Per cent. metallic iron 55.65.

IRON ORE from forks of Paint creek, three miles above mouth of Stoney creek, Cambria county.

Description.—Structure flattened, nodular, compact; color slate blue; color light buff.

Composition in 100 parts:

Carbonate of iron,	60.90
Per oxide of iron,	12.60
Carbonate of lime,	3.00
Alumina,	2.00
Silica and insoluble matter,	14.74
Water,	6.50
Loss,	0.26
	100.00

Per cent. metallic iron 38.22.

IRON ORE from near the conglomerate, at Karthaus, Clearfield creek, one mile S. of Squire Warner's.

Description.—Nodular, concentric; crust hematitic; nucleus filled with sparry iron and pulverulent oxide; color mottled chesnut brown; lustre glimmering.

Composition in 100 parts:

Carbonate of iron,	19.86
Per oxide of iron,	34.80
Carbonate of lime,	4.50
Alumina,	1.70
Silica and insoluble matter,	30.40
Manganese,	a trace
Water,	8.20
Loss,	0.54
	100.00

Per cent. metallic iron 33.95.

IRON ORE from run west of Clearfield creek, two miles above mouth, on Mr. Wilson's land, Clearfield county.

Description.—Structure somewhat nodular; outside friable, inside more compact; color mottled grey; contains sparry iron.

Composition in 100 parts:

Carbonate of iron,	50.48
Per oxide of iron,	12.79
Carbonate magnesia, with a trace of carbonate of manganese,	2.43
Carbonate of lime,	0.70
Insoluble matter,	29.01
Water,	4.59
	100.00

Per cent. metallic iron 32.77.

IRON ORE three miles above Clearfield on river bank, Clearfield county.

Description.—Moderately compact, semi-crystalline; color dark blue, outside rusty.

Composition in 100 parts:

Carbonate of iron,	56.83
Per oxide of iron,	13.21
Carbonate of manganese,	1.13
Carbonate of magnesia,	1.26
Alumina,	a trace
Insoluble matter,	24.41
Water,	3.16
	100.00

Per cent. metallic iron 36.11.

Iron Ore, a variety of the above and from the same locality.

Description.—Nodular, compact—when broken exhibiting small cavities coated with drusy quartz and iron pyrites, in minute cubical crystals; color of mass dull blue. The portion selected for analysis was taken from the more compact and homogeneous part in which no specks of pyrites could be observed.

Composition in 100 parts:

Carbonate of iron,	66.37
Per oxide of iron,	20.49
Carbonate of manganese,	2.25
Carbonate of lime,	1.07
Carbonate of magnesia,	2.08
Alumina,	a trace
Sulphur,	a trace
Water,	1.64
Silica and insoluble matter,	6.10
	100.00

Per cent. metallic iron 45.64.

Iron Ore from Buffalo creek, Horner's mill, Armstrong county.

Description.—Nodular, or ball ore, compact, close grained; color interior brownish blue, exterior brown.

Composition in 100 *parts:*

Carbonate of iron,	68.32
Carbonate of lime,	15.54
Carbonate of magnesia,	1.35
Carbonate of manganese,	a trace
Alumina,	a trace
Insoluble matter,	10.58
Water,	4.00
Loss,	0.21
	100.00

Per cent. metallic iron 32.95.

IRON ORE from same locality as above, but more siliceous.

Composition in 100 *parts:*

Carbonate of iron,	54.33
Carbonate of lime,	a trace
Carbonate of magnesia,	a trace
Alumina,	0.50
Insoluble matter,	40.90
Water,	4.00
Loss,	0.27
	100.00

Per cent. metallic iron 25.34.

From the statements above given of the composition of our iron ores, including the characteristic varieties from nearly all the ore bearing formations in the state, it would appear that they belong chiefly to three distinct species: *magnetic iron ore, brown oxide of iron*, and *compact carbonate of iron*, the two latter kinds being much the most extensively diffused. The magnetic ores occur only in the south-eastern division of the state, either among the primary rocks or adjacent to the trap dykes of the middle secondary region. The compact carbonate of iron, being the ore which in nearly all countries is confined principally to the coal formation, abounds mainly in our anthracitic and bituminous coal measures, where it exists in many of the basins in a quantity truly inexhaustible. The extensive and valuable deposite situated in the bottom layers of F. VIII., in Franklin, Huntingdon and Juniata counties, which was proved by us to be a regular and continuous deposite, is also a variety of the compact carbonate of iron, though, like the similar ore of the coal measures, it passes into the per oxide at its outcrop.

The other class of ores, varieties of the brown oxide or per oxide of iron, prevail on the other hand in greater or less abundance in all the formations within the State, valuable deposites occurring in association not only with many of the older secondary rocks of the Appalachian region, but likewise with the gneiss and marble of the primary district on the one side and the coal measures on the other.

In presenting the foregoing analyses, it is requisite to remind the reader that the different ores here described will not retain the same relation to each other as respects the per centage of iron in them after they have undergone the usual roasting preparatory to entering the furnace, the carbonates losing much more extraneous matter by this process than the per oxide ores. The chief volatile constituent in the latter class, it will be seen, is *water*, which seldom amounts to fifteen per cent. upon the raw ore, whereas in the other class, besides a small quantity of water, there prevails, varying with the richness of the ore, a large proportion of carbonic acid gas, much of which is extricated during the preliminary roasting. Thus if we omit the consideration of the gain from detaching the externally adhering soil and other matters, the one species will not often improve, by roasting, in richness more than five or seven per cent. while the other class will sometimes exhibit an improvement of as much as ten or twelve per cent.

It should be remarked that all forms of the carbonate of iron show a natural tendency to loose their carbonic acid and pass to the condition of the brown or per oxide of iron by exposure to atmospheric agencies. Such ores will therefore be considerably richer in iron at their outcrop than a few feet in from the surface. Inattention to this point is a fertile source of mistake, in estimating the average product of beds of ore discovered in the coal measures. We observe a similar increase in richness at its outcrop in the calcareous, fossiliferous ore of F. V., but this arises from the solution and removal by percolation of the carbonate of lime which is an important ingredient in the harder varieties of this ore. In it the iron is already in the state of the red per oxide, not of a carbonate of iron.

VII. *Analysis of a Zinc and Lead Ore.*

Analysis of an impure silicate of zinc from the bank of the Susquehanna, opposite Selinsgrove, Northumberland county.

Description.—Occurs in irregular amorphous shaped masses, of an earthy and sometimes semi-crystalline appearance, containing disseminated portions of sulphuret of lead, which are embedded in a greyish, imperfectly crystallized silicate of zinc. An average portion of a large mass furnished in the 100 parts

Oxide of zinc,	60.50
Sulphuret of lead,	10.00
Oxide of iron and alumina,	0.50
Silica,	23.00
Water,	5.60
Loss,	0.40
	100.00

This ore contains of metallic zinc 50.40, and of metallic lead 8.66.

VIII. *Analyses of Cast Iron.*

Cast Iron made in the summer of 1839, at Farrandsville, from two parts Larry's creek ore and two and a half parts Catawissa ore and five parts limestone.

Description.—Minutely granular and of uniform texture throughout; color bluish grey. So tough under the hammer as to be difficult to break into small pieces.

Composition in 100 parts:

Pure iron,	93 91
Silicium,	2.40
Manganesium,	0.07
Aluminium,	0.50
Carbon,	3.12
Sulphur,	a trace
	100.00

Cast Iron from Danville.

Description.—Texture soft, brilliantly crystalline; grey.

Composition in 100 parts:

Pure iron,	94.94
Silicium,	2.03
Manganesium,	0.05
Aluminium,	a trace
Carbon,	2.98
	100.00

Section II.

Analyses of Coals.

I. *Anthracite Coals.*

Coal from Nesquehoning mines, from the 10th feet vein, east drift, Northampton county. Structure irregularly columnar; fracture irregularly conchoidal; color greyish black; lustre splendent.

Composition in 100 parts:

Volatile matter,	6.40
Carbon,	86.60
Ashes, white,	7.00
	100.00

Coal from Summit mines of the Lehigh Company, from a vein said to be 14 feet thick, Northampton county. Structure massive, compact; color black, metallic; lustre brilliant.

Composition in 100 parts:

Volatile matter,	7.50
Carbon,	88.50
Ashes, dull white,	4.00
	100.00

Coal from Summit mines, Lehigh Company, Northampton county, hardest variety. Structure dense, laminated; fracture smooth, somewhat conchoidal; color metallic black; lustre splendent.

Composition in 100 parts:

Volatile matter, - - - - - - - -	6.60
Carbon, - - - - - - - -	87.70
Ashes, white, - - - - - - - - - - - - - -	5.70
	100.00

Coal from Tamaqua coal mines on east side of the river, called vein D east, Schuylkill county. Texture nearly compact, somewhat slaty; fracture conchoidal; greyish or iron black; lustre splendent. Specific gravity 1.57.

Composition in 100 parts:

Volatile matter, - - - - - - - -	5.03
Carbon, - - - - - - - -	92.07
Ashes, white, - - - - - - - - -	2.90
	100.00

Coal from Tamaqua mines, vein E east, Schuylkill county. Texture compact; fracture conchoidal; greyish black; lustre splendent. Specific gravity 1.60.

Composition in 100 parts:

Volatile matter, - - - - - - -	4.54
Carbon, - - - - - - - -	89.20
Ashes, perfectly white, - - - -	6.26
	100.00

Coal from Tamaqua coal mines, R. vein, in the Sharp mountain. Texture compact, tendency to lamination; greyish black; lustre metallic, splendent. Specific gravity 1.55.

Composition in 100 *parts:*

Volatile matter,	7.55
Carbon,	87.45
Ashes, white,	5.10
	100.00

Coal from Tuscarora mines, from second drift south of Jackson's mine, Schuylkill county. Structure slightly laminated, tolerably compact; irregular conchoidal fracture; color black; lustre splendent.

Composition in 100 *parts:*

Volatile matter,	7.50
Carbon,	88.20
Ashes, pinkish brown,	4.30
	100.00

Coal from the Schenoweth vein, Pottsville, Schuylkill county. Structure compact; irregular fracture; color black; lustre splendent. Specific gravity 1.50.

Composition in 100 *parts:*

Volatile matter,	1.40
Carbon,	94.10
Ashes, light brown,	4.50
	100.00

Coal from Neeley's Tunnel, third vein, Schuylkill county. Texture compact; iron black; fracture conchoidal; lustre splendent. Sp. gr. 1.55.

Composition in 100 *parts:*

Volatile matter,	5.40
Carbon,	89.20
Ashes, light yellow color,	5.40
	100.00

Coal from Sharp mountain, Pinegrove. Texture laminated; grey black; fracture splintery; lustre splendent. Sp. gr. 1.54.

Composition in 100 parts:

Volatile matter,	7.15
Carbon,	80.57
Ashes,	3.28
	100.00

Coal from Black Spring Gap, Dauphin county, twenty-five miles east of the river. Massive, friable; fracture irregular; color iron black; lustre somewhat splendent. Sp. gr. 1.44.

Composition in 100 parts:

Volatile matter,	9.53
Carbon,	82.47
Ashes, yellow white color,	8.00
	100.00

Coal from Lea vein, 7 feet thick, near Black Spring Gap, Dauphin county. Structure laminated, brittle, black, shining. Specific gravity 1.35.

Composition in 100 parts:

Volatile matter,	8.96
Carbon,	85.84
Ashes, cream color,	5.20
	100.00

Coal from Grey vein, 16.7 feet thick, near Black Spring Gap. Massive; fracture irregular; color black; considerable lustre.—Specific gravity 1.44.

Composition in 100 parts:

Volatile matter,	9.78
Carbon,	81.02
Ashes, light orange,	9.20
	100.00

Coal from Grey vein, near Black Spring Gap; included *grey band*. Structure somewhat fibrous, brittle; color grey black, smutty; dull metallic lustre. Specific gravity 1.33.

Composition in 100 *parts:*

Volatile matter,	11.40
Carbon,	81.40
Ashes, pale ochreous color,	7.20
	100.00

Coal from Peacock vein, Gold Mine Gap, Dauphin county, twenty-five miles east of the river. Structure massive, with a tendency to columnar fracture, angular; color black, shining, irised. Specific gravity 1.41.

Composition in 100 *parts:*

Volatile matter,	10.95
Carbon,	82.15
Ashes, light orange color,	6.90
	100.00

Coal from the Heister vein, Gold Mine Gap, Dauphin county. Structure massive; striæ distinct; color jet black; lustre shining. Specific gravity 1.41.

Composition in 100 *parts:*

Volatile matter,	10.43
Carbon,	81.47
Ashes, pale yellow color,	8.10
	100.00

Coal from vein supposed to be the Peacock vein, W. side of Raush Gap, Dauphin county, twenty-one miles east of the river. Structure massive, friable, small columnar; fracture irregular; color black; iridescent. Specific gravity 1.45.

Composition in 100 parts:

Volatile matter,	10.57
Carbon,	77.23
Ashes, pale orange,	12.30
	100.00

Coal from Yellow Spring Gap, Dauphin county, sixteen miles east of the Susquehanna. Structure slaty, somewhat brittle; fracture irregular; black; lustre shining. Specific gravity 1.41.

Composition in 100 parts:

Volatile matter,	10.95
Carbon,	79.55
Ashes, pale yellow color,	9.50
	100.00

Mr. R. C. Taylor gives an analysis of a coal from Yellow Spring Gap, which contains 14.80 per cent. of volatile matter. Consult two reports on this part of the basin by Richard C. Taylor, 1840.

Coal from Rattling run, Dauphin county, thirteen miles east of the river. Massive, regular fracture, tendency to lamination, cross fracture shining, black; between the laminæ, lustre feeble.

Composition in 100 parts:

Volatile matter,	13.75
Carbon,	74.55
Ashes in the coal,	11.70
	100.00

Coke light and spongy.

Coal from Big flats, Dauphin county, nine miles east of the river from the shaft. Massive, irregularly laminated; fracture irregular; striæ small and distinct; jet black and considerable lustre.

Composition in 100 *parts:*

Volatile matter,	15.06
Carbon,	76.94
Ashes, orange,	8.00
	100.00

Makes good coke.

Coal from Lykens Valley, third bed, Dauphin county. Texture, laminated, brittle; fracture fibrous; color jet black, shining.

Composition in 100 *parts:*

Volatile matter,	8.85
Carbon,	88.25
Ashes,	2.90
	100.00

Coal from Shamokin coal mines, Snyder's mine. Structure massive, compact; fracture laminated; beautifully iridescent.

Composition in 100 *parts:*

Volatile matter,	6.10
Carbon,	89.90
Ashes,	4.00
	100.00

Coal from Wilkesbarre, Luzerne county, Warden's vein. Texture compact, iron black; lustre, splendent; fracture conchoidal. Specific gravity, 1.403.

Composition in 100 *parts:*

Volatile,	7.68
Carbon,	88.90
Ashes,	3.49
	100.00

COAL from Wilkesbarre coal basin, Carbondale mines, Luzerne county. Texture laminated; laminæ compact; iron black; fracture somewhat irregular; lustre brilliant, metallic. Specific gravity 1.404.

Composition in 100 *parts:*

Volatile matter,	7.07
Carbon,	90.23
Ashes, greyish,	2.70
	100.00

The first twenty analyses of the foregoing series, will exhibit the average composition of the coal in the different parts of the first, or great southern anthracite basin, the specimens which were selected with this view having been chosen from various localities, at tolerably regular intervals from near its eastern extremity to within a few miles of its western termination. The public is already familiar with the fact of the general increase of softness in the coal of this basin as we proceed westward. The above results will display a similar augmentation in the quantity of the volatile materials in the coal, though it does not follow that these two features are in exact proportion to each other, as a single neighborhood will shew beds of coal differing considerably in both these particulars the hardness and volatile matter, and where no such dependence of the one upon the other can be remarked. I reserve for a future occasion the more full discussion of this curious subject, of the gradations noticeable in the character of the coal in many of our coal fields, confining myself at present to the striking variation which occurs towards the western extremity of this southern anthracite basin.

From the Lehigh westward as far as the Swatara, we rarely find the volatile matter to amount to more than about *seven and a half per cent.* in the coal, while its *average* quantity in our anthracite generally may be stated at about *six per cent;* nearly the whole of this appears to be water. Advancing a few miles west of the Swatara, we enter a section of the basin where the coal acquires a decided increase in the amount of its volatile matters. At Black Spring Gap, twenty-six miles east of the Susquehanna, this is first distinctly manifested, the quantity there being about *ten* per cent. A portion of this is probably free gaseous matter, not bitumen, or if this is present the quantity is too small to impart to the coal any tendency to melt or make a coke. But about ten miles further westward, we meet with coal, in the prolongation of the very same veins, having as much as from *ten* to *fifteen* per cent. of volatile matter, and a part of this obviously bitumen. From the Yellow Spring gap to the western extremity of the basin, the largest proportion of volatile matter which we have yet noticed in the coal is about *fifteen* per cent. Where it possesses this amount it has all the properties of a true bituminous coal, burning with a brilliant, though not very enduring blaze, and yielding, when properly treated, a good spongy coke, well adapted to manufacturing purposes.

II. Bituminous Coals.

Broad Top Basin.

Coal from Hopewell Furnace mines, Broad Top mountain, Bedford county. Massive, striæ distinct, somewhat columnar, shining jet black, in parts iridescent.

Analysis in 100 *parts:*

Volatile matter, - - - - -	11.20
Coke, - - - - - - - -	88.80
	100.00

Ashes in the coal, 4.00.

Coke spongy but hard.

The coal of the Broad Top basin exhibits an interesting confirmation of the general law early noticed by me, that as we advance towards the N. W. the coals acquire more and more bitumen. This coal field, occupying a position intermediate between the range of the anthracite basins on the one hand and the bituminous basins beyond the Allegheny mountain on the other, its coal displays a corresponding or intermediate proportion of bitumen.

First Basin N. W. of the Allegheny Mountain.

Coal from bed of Lick run, Lycoming county. Laminated, somewhat brittle, shining black, between laminæ dull black.

Analysis in 100 *parts:*

Volatile matter,	20.72
Coke,	79.28
	100.00

Ashes in the coal 13.07, greyish pink.

Coal from Queen's run, two miles below Farrandsville, Clinton county. Irregularly columnar, brittle; color jet black, shining with thin films of charcoal.

Analysis in 100 *parts:*

Volatile matter,	21.50
Coke,	78.28
	100.00

Ashes in the coal, 4.60.

Coal from Snow Shoe mine, Centre county. Massive, brittle, irregular fracture; tendency to columnar structure; lustre shining jet black.

Composition in 100 *parts:*

Volatile matter,	21.20
Coke,	78.80
	100.00

Ashes in the coal, 2.07.

Coke highly intumescent and spongy.

Coal from Moshannon creek, near Philipsburg, Clearfield county. Structure small columnar, somewhat fibrous; striæ distinct; lustre jet black and shining.

Composition in 100 *parts:*

Volatile matter,	29.50
Coke,	70.50
	100.00

Ashes in the coal, 6.10.

Coal from Steed's mine, sixteen miles from Philipsburg, Centre county. Friable, irregularly columnar; striæ distinct; jet black, with considerable lustre.

Composition in 100 *parts:*

Volatile matter,	20.40
Coke,	79.60
	100.00

Ashes in the coal, 11.20.

Coke compact; ashes light cream color.

Coal from Leech's mine, seventeen and a half miles from Philipsburg, Centre county. Friable; structure columnar; jet black with much lustre.

Composition in 100 *parts:*

Volatile matter,	20.32
Coke,	79.68
	100.00

Ashes in the coal, 11.75.

Second Basin N. W. of the Allegheny Mountain.

Coal from upper part of large bed, Ralston, Lycoming county. Columnar, irregular cubical; fracture irregular; color shining black, in parts dull.

Composition in 100 *parts:*

Volatile matter,	20.50
Coke,	79.50
	100.00

Ashes in the coal, 5.00.

Coal from Karthaus, upper seam, Clearfield county. Structure columnar, cubical, friable; fracture irregular; color jet black; lustre considerable.

Composition in 100 *parts:*

Volatile matter,	13.00
Coke,	87.00
	100.00

Ashes in the coal, 8.80 brownish yellow.

Coal from Karthaus, lower seam. External characters similar to the above.

Composition in 100 *parts:*

Volatile matter,	24.80
Coke,	75.20
	100.00

Ashes in the coal, 4.70, brownish yellow.

Coal from Reed's, six feet vein, Curwinsville, Clearfield county. Columnar, cubical, brittle; fracture irregular; color jet black with great lustre.

Composition in 100 *parts:*

Volatile matter,	27.00
Coke,	73.00
	100.00

Ashes in the coal, 5.30.

Third Basin N. W. of the Allegheny Mountain.

Coal from the bed now worked at Bear creek, Blossburg, Tioga county. Columnar, somewhat compact containing occassional thin seams of charcoal; lustre jet black and very considerable.

Composition in 100 *parts:*

Volatile matter,	32.00
Coke,	68.00
	100.00

Ashes in the coal 5.20.

Coal from five feet vein, Warner's, Caledonia, Clearfield county. Structure laminated, cubical, brittle; fracture irregular; color jet black and shining.

Composition in 100 *parts:*

Volatile matter,	37.00
Coke,	63.00
	100.00

Ashes in the coal 8.50.

Coal from three feet seam, Warner's, Caledonia, Clearfield county. Soft, columnar; lustre jet black and very considerable; fracture irregular.

Composition in 100 parts:

Volatile matter,	38.20
Coke,	61.80
	100.00

Ashes in coal, 7.20.

Coal from Blairsville, large bed, Westmoreland county. Structure laminated, columnar, somewhat hard and compact; color shining jet black.

Composition in 100 parts:

Volatile matter,	31.00
Coke,	69.00
	100.00

Ashes in the coal, 4.00.

Fourth or great Western Basin.

Coal from Sandy ridge, four miles from Shippensville, Clarion county. Massive; striæ indistinct; fracture cubical; black; lustre feebly shining.

Composition in 100 parts:

Volatile matter,	43.20
Coke,	56 80
	100.00

Ashes in the coal 7.00; light grey.

Cannel Coal from six miles east of Franklin, Venango county. Composed of laminæ, breaks with a uniform cleavage; cross fracture conchoidal; surface smooth, dull black, with little lustre.

Composition in 100 *parts:*

Volatile matter,	52.78
Coke,	47.22
	100.00

Ashes in the coal 17.68.

Cannel Coal from Greersburg, Beaver county. Composed of thick regular laminæ; cross fracture conchoidal; surface smooth, dull black.

Composition in 100 *parts:*

Volatile matter,	36.00
Coke,	64.00
	100.00

Ashes in the coal 33.88.

Coal from Conneaut Lake, Crawford county. Slaty, laminated; fracture irregular; somewhat brittle; color jet black shining.

Composition in 100 *parts:*

Volatile matter,	38.75
Coke,	61.25
	100.0

Ashes in the coal 1.80 reddish brown.

Coal from near Greenville, Mercer county. Laminated, slaty; cross fracture splintery; brittle; color shining jet black.

Composition in 100 *parts:*

Volatile matter,	40.50
Coke,	59.50
	100.00

Ashes in the coal 1.7 brownish yellow.

Coal from near Orangeville, Mercer county. Structure laminated; somewhat rusty between laminæ; fracture regular; color black, sometimes shining and iridescent.

Composition in 100 *parts:*

Volatile matter, - - - - - -	43.75
Coke, - - - - - - - -	56.25
	100.00

Ashes in the coal 2.80 dark brown.

A comparison of the foregoing analyses of the bituminous coals from the several basins northwest of the Allegheny mountain, discloses the highly interesting general fact of the progressive increase in the quantity of their bitumen, as we advance northwestward. Thus, the first group of coals selected from various parts of the basin nearest the Allegheny mountain, shows an average proportion of bitumen of about *twenty-one* per cent; the second or next basin to the N. W. a somewhat higher proportion; the third basin or range of basins gives as much as *thirty-four* per cent; and the fourth or great western basin of the Allegheny and Monongahela, nearly *forty* per cent.

This remarkable change in the composition of the coal as we proceed from the S. E. to the N. W. is not confined only to the basins of Pennsylvania, but prevails, I have reason to believe, throughout the whole length of the vast bituminous coal field which ranges from our State to the northern boundary of Alabama. I defer to a future opportunity an inquiry into the circumstances which formed and subsequently modified this truly prodigious deposite of carbonaceous matter.

Sulphur.—All the varieties of coal contain more or less *sulphur*, no doubt in combination with iron, under the form of iron pyrites disseminated throughout the coal. The amount of this substance materially influencing the value of different coals, when applied to metallurgic or other economic uses, it has been deemed advisable to make a series of comparative experiments to ascertain the proportions in which it exists in the two most widely different varieties of our coal, the anthracite and bituminous. From numerous chemical examinations made in reference to the point, the following results are selected. The specimens were clean and free from any adhering slaty matter.

Anthracite Coal from Pottsville, average specimen of white ash:

Contains in 100 parts—Sulphur, - - - 0.60

Anthracite Coal from Peach mountain, average specimen of red ash:

Contains in 100 parts—Sulphur, - - - 0.48

Anthracite Coal from Lehigh, (hard coal,) average specimen of white ash:

Contains in 100 parts—Sulphur, - - - 0.91

Bituminous Coal from Karthaus, highly bituminous:

Contains in 100 parts—Sulphur, - - - 2.70

Bituminous Coal Blairsville, Westmoreland county:

Contains in 100 parts—Sulphur, - - - 2.60

Analyses of Limestones.

It will be seen from the following analyses that a large portion of our limestones contain a considerable amount of *magnesia.* Though it is now satisfactorily ascertained that the presence of this earth in lime does not in any way interfere with its useful properties when employed as a fertilizing agent, its hurtfulness as a *flux* in the process of making iron is well established.

Aware of the very frequent oversights committed by the proprietors of our numerous iron works in using magnesian in place of pure limestone, and apprized by experience of the extreme difficulty of distinguishing the fit varieties from the unfit by their appearance merely, I shall endeavor in my final report to produce an extensive series of chemical analyses of the limestones employed at the various furnaces. At present I offer a few results, more with a view to draw the attention of iron masters to this too much neglected subject of magnesia, than with the desire to exhibit a large body of analyses, for which there is not space in the limits of an annual report.

Limestones from Formation II.

Limestone from Mr. Keller's quarry, below Easton. Color bluish grey; compact, close grained, semi-crystalline; fracture slightly conchoidal, angular.

Composition in 100 *parts:*

Carbonate of lime,	51.02
Carbonate of magnesia,	43.28
Alumina and oxide of iron,	0.50
Insoluble matter,	4.80
Water and loss,	0.40
	100.00

Limestone from Hepburn and Able's quarry, below Easton. Color light grey; compact; texture fine grained; fracture irregularly conchoidal, angular.

Composition in 100 *parts:*

Carbonate of lime,	55.00
Carbonate of magnesia,	31.40
Alumina and oxide of iron,	2.30
Insoluble matter,	10.80
Water,	0.50
	100.00

Limestone from Judge Porter's quarry, on the Delaware below Easton. Color dark bluish grey; compact; moderately fine texture, sub-crystalline; fracture sharp conchoidal.

Composition in 100 *parts:*

Carbonate of lime,	48.30
Carbonate of magnesia,	42.15
Alumina and oxide of iron,	4.30
Insoluble matter,	4.80
Water,	0.45
	100.00

LIMESTONE from Judge Porter's farm, south of Easton. Color dull bluish grey; compact, close grained; fracture irregular; weathered surface ochreous.

Composition in 100 *parts:*

Carbonate of lime, - - - - - -	34.10
Carbonate of magnesia, - - - - -	37.90
Alumina and oxide of iron, - - - -	1.30
Insoluble matter, - - - - - -	26.30
Water, - - - - - - - -	0.40
	100.00

LIMESTONE from Mr. Shrie's, four miles below Easton. Color grey; texture moderately compact, sub-crystalline; fracture somewhat even; angles sharp.

Composition in 100 *parts:*

Carbonate of lime, - - - - - -	48.70
Carbonate of magnesia, - - - - -	41.76
Alumina and oxide of iron, - - - -	1.30
Insoluble matter, - - - - - -	7.80
Water, - - - - - - - -	4.40
	100.00

LIMESTONE from Harman's quarry, four miles below Easton. Color grey; texture sub-crystalline; fracture irregular, angular.

Composition in 100 *parts:*

Carbonate of lime, - - - - - -	50.80
Carbonate of magnesia, - - - - -	47.10
Alumina and oxide of iron, - - - -	0.50
Insoluble matter, - - - - - -	1.00
Water, - - - - - - - -	0.50
Loss, - - - - - - - -	0.10
	100.00

Limestone from near Biery's bridge, on Lehigh river, used as flux in the Lehigh Crane Iron works; color greyish blue; texture compact, fine grained; sub-crystalline; fracture slightly conchoidal, angular.

Composition in 100 *parts:*

Carbonate of lime, - - - - - -	52.70
Carbonate of magnesia, - - - - -	33.78
Alumina and oxide of iron, - - - -	2.80
Insoluble matter, - - - - - -	10.30
Water, - - - - - - - -	0.42
	100.00

Limestone from near Biery's bridge, three miles above Allentown, Lehigh county, used as a flux in the Crane iron works. Color grey; texture distinctly crystalline and sparry; fracture irregular.

Composition in 100 *parts:*

Carbonate of lime, - - - - - -	93.40
Carbonate of magnesia, - - - -	none
Alumina and oxide of iron, - - - -	1.80
Insoluble matter, - - - - - -	4.30
Water, - - - - - - - -	0.50
	100.00

Limestone used in Trexler furnace, Lehigh county. Color light grey; moderately compact and fine grained; intersected by veins of white calc spar; fracture somewhat conchoidal, angles sharp.

Composition in 100 *parts:*

Carbonate of lime, - - - - - -	50.30
Carbonate of magnesia, - - - - -	41.30
Alumina and oxide of iron, - - - -	3.80
Insoluble matter, - - - - - -	4.30
Water, - - - - - - - -	0.30
	100.00

LIMESTONE from Davy Shall's quarry, near his forge, west branch of Perkiomen creek, Berks county. Color dull light grey, sub-crystalline; compact; fracture angular.

Composition in 100 *parts:*

Carbonate of lime,	53.17
Carbonate of magnesia,	43.90
Alumina and oxide of iron,	0.70
Insoluble matter,	1.95
Water and loss,	0.28
	100.00

LIMESTONE from George Keim's quarry, Pike township, Berks county. Color light bluish grey; structure somewhat laminated; texture sub-crystalline; fracture angular; contains in some parts small crystalline nodules of fluor spar; part analysed free from these.

Composition in 100 *parts:*

Carbonate of lime,	88.34
Carbonate of magnesia,	7.80
Alumina and oxide of iron,	0.24
Insoluble matter,	2.81
Water,	0.80
Loss,	0.01
	100.00

LIMESTONE from eastern part of the town of Carlisle. Light dove color; very compact, and fine grained, disposed in regular laminæ; fracture very slightly conchoidal.

Composition in 100 *parts:*

Carbonate of lime,	92.74
Carbonate of magnesia,	none
Alumina and oxide of iron,	1.00
Insoluble matter,	5.80
Water,	0.40
Loss,	0.06
	100.00

Limestone from near New Market, half a mile below Yellow Breeches creek, Cumberland Valley. Color dark grey; texture compact, sub-crystalline; fracture irregular, angular.

Composition in 100 *parts:*

Carbonate of lime, - - - - -	92.83
Carbonate of magnesia, - - - -	none
Alumina and oxide of iron, - - -	1.00
Insoluble matter, - - - - - -	5.80
Water, - - - - - - -	0.37
	100.00

Limestone used as a flux in Mary Ann furnace, Cumberland county. Color light; texture moderately close, semi-crystalline; fracture irregular.

Composition in 100 *parts:*

Carbonate of lime, - - - -	89.61
Carbonate of magnesia, - - - -	9.45
Alumina and oxide of iron, - - - -	traces
Insoluble matter, - - - - -	1.49
Water, - - - - - - -	0.45
	100.00

Limestone used as a flux in Carlisle iron works. Color light blue; compact, slightly laminated; fracture sharp angular.

Composition in 100 *parts:*

Carbonate of lime, - - - - -	78.37
Carbonate of magnesia, - - - -	none
Alumina and oxide of iron, - - -	0.40
Insoluble matter, - - - - - -	20.80
Water, - - - - - - -	0.43
	100.00

Limestone from railroad, quarter of a mile north-east of Shippensburg, Cumberland county. Color light dove; texture very close and fine grained; fracture smooth conchoidal, angular.

Composition in 100 *parts:*

Carbonate of lime,	87.20
Carbonate of magnesia,	none
Alumina and oxide of iron,	traces
Insoluble matter,	12.30
Water,	0.30
Loss,	0.20
	100.00

Limestone from one mile north from Mercersburg, Franklin county. Color light dove; texture compact, close grained, intersected by minute veins of white calc spar; fracture somewhat conchoidal, angular.

Composition in 100 *parts:*

Carbonate of lime,	46.10
Carbonate of magnesia,	39.49
Alumina and oxide of iron,	2.60
Insoluble matter,	11.30
Water,	0.51
	100.00

Limestone from south-east of Waynesburg, Franklin county. Color dark grey; moderately fine grained, sub-crystalline; fracture harsh, conchoidal.

Composition in 100 *parts:*

Carbonate of lime,	86.50
Carbonate of magnesia,	none
Alumina and oxide of iron,	4.80
Insoluble matter,	8.30
Water	0.40
	100.00

LIMESTONE: white marble from three miles south-east of Waynesburg, Rogers's quarry, above Stoner's mill, Cumberland valley, Franklin county. Color cream white; texture beautifully compact and fine grained, exhibiting a very minute crystalline structure; fracture tendency to conchoidal.

Composition in 100 *parts:*

Carbonate of lime,	98.80
Carbonate of magnesia,	none
Alumina and oxide of iron,	0.80
Insoluble matter,	a trace
Water,	0.40
	100.00

LIMESTONE used at Pond furnace, (Moore's,) Franklin county. Color dark blue; texture compact and fine grained; fracture conchoidal, angular, occasionally exhibits extremely minute crystals of yellow iron pyrites.

Composition in 100 *parts:*

Carbonate of lime,	36.50
Carbonate of magnesia,	26.20
Alumina and oxide of iron,	5.00
Sulphur,	a decided trace
Insoluble matter,	27.30
Water,	5.00
	100.00

LIMESTONE used as a flux at Caledonia furnace, Franklin county. Color bluish grey; texture moderately fine grained, semi-crystalline; fracture irregularly slaty.

Composition in 100 *parts:*

Carbonate of lime,	74.69
Carbonate of magnesia,	23.52
Alumina and oxide of iron,	traces
Insoluble matter,	1.49
Water,	0.30
	100.00

Limestone from four miles east of Chambersburg, near Gettysburg turnpike, tried as a flux in Caledonia furnace, but not found good. Color dull dark grey; texture coarse, and slightly sparry; fracture irregularly conchoidal.

Composition in 100 *parts:*

Carbonate of lime,	79.63
Carbonate of magnesia,	17.40
Alumina and oxide of iron,	traces
Insoluble matter,	2.64
Water,	0.60
Excess,	0.27
	100.00

Limestone used as a flux in Carrick furnace, Path Valley, Franklin county. Color dove; compact, fine grained, somewhat sparry in portions; fracture smooth conchoidal.

Composition in 100 *parts:*

Carbonate of lime,	94.71
Carbonate of magnesia,	none
Alumina and oxide of iron,	traces
Insoluble matter,	4.94
Water,	0.35
	100.00

Limestone from Kishacoquillas valley, at the Iron mine near Allenville, on the anticlinal axis. Color light blue, dull; compact; fracture conchoidal.

Composition in 100 *parts:*

Carbonate of lime,	46.64
Carbonate of magnesia,	36.31
Alumina and oxide of iron,	0.91
Insoluble matter,	15.83
Water,	0.31
	100.00

Limestone from near Springfield furnace, Huntingdon county, obtained about four hundred yards from the base of Lock mountain. Color dull dark blue; compact, fine grained, somewhat sparry; fracture conchoidal.

Composition in 100 parts:

Carbonate of lime, - - - - - -	99.20
Carbonate of magnesia, - - - - -	none
Alumina and oxide of iron, - - - -	0.50
Insoluble matter, - - - - - -	a trace
Water, - - - - - - - -	0.30
	100.00

Limestone from same locality, five hundred yards from base of Lock mountain. Color light dove; compact fine grained; weathered surface light ochreous color; fracture large conchoidal, angular.

Composition in 100 parts:

Carbonate of lime, - - - - - -	52.20
Carbonate of magnesia, - - - - -	34.50
Alumina and oxide of iron, - - - -	1.80
Insoluble matter, - - - - - -	11.30
Water, - - - - - - - -	0.20
	100.00

Limestone from same locality, six hundred and fifty yards from the base of Lock mountain. Color light grey; compact, texture; moderately fine grained; weathered surface buff; fracture even, angular.

Composition in 100 parts:

Carbonate of lime, - - - - - -	54.80
Carbonate of magnesia, - - - - -	35.30
Alumina and oxide of iron, - - - - -	4.00
Insoluble matter, - - - - - -	5.60
Water, - - - - - - - -	0.30
	100.00

LIMESTONE from same locality, eight hundred yards from base of Lock mountain. Color brownish grey; texture compact, moderately fine grained, somewhat sparry; fracture irregular, angular.

Composition in 100 *parts:*

Carbonate of lime, - - - - - -	47.83
Carbonate of magnesia, - - - -	36.77
Alumina and oxide of iron, - - -	2.80
Insoluble matter, - - - - - -	12.30
Water, - - - - - - - - - -	0.30
	100.00

Limestone from F. V.

LIMESTONE from thirty feet above the iron ore at Matilda furnace, two miles west of Newton Hamilton, Huntingdon county. Color blue; compact, sub-crystalline; fracture conchoidal.

Composition in 100 *parts:*

Carbonate of lime, - - - - - -	85.26
Carbonate of magnesia, - - - - -	4.67
Per oxide of iron, - - - - - -	1.97
Oxide of manganese, - - - - -	a trace
Insoluble matter, - - - - - -	7.97
Water, - - - - - - - - -	0.13
	100.00

Limestones from F. VI.

LIMESTONE from neighborhood of Millhall, flux used at Farrandsville. Color mottled grey and white; sparry, somewhat saccharoidal; fracture irregular; few fossils.

Composition in 100 *parts:*

Carbonate of lime, - - - - - -	96.80
Carbonate of magnesia, - - - - -	0.50
Alumina and oxide of iron, - - -	traces
Insoluble matter, - - - - - - -	2.30
Water, - - - - - - - - -	0.40
	100.00

Limestone from Hopewell furnace, Bedford county, used as a flux. Color blue black; compact and close grained; fracture conchoidal fossiliferous.

Composition in 100 *parts:*

Carbonate of lime,	92.00
Carbonate of magnesia,	a trace
Oxide of iron and alumina,	a trace
Insoluble matter,	3.50
Water,	4.50
	100.00

Limestone from Loyalsock, near Williamsport, used as a flux at the Astonville furnace, Lycoming county. Color bluish black; compact; fracture conchoidal; fossiliferous.

Composition in 100 *parts:*

Carbonate of lime,	98.30
Carbonate of magnesia,	a trace
Alumina and oxide of iron,	none
Insoluble matter,	1.30
Water,	0.40
	100.00

Limestone from eight miles east of Pine Grove, Schuylkill county. Color dull lead blue; texture somewhat coarse, sub-crystalline, sparry; fracture irregular, angular.

Composition in 100 *parts:*

Carbonate of lime,	49.90
Corbonate of magnesia,	7.10
Alumina and oxide of iron,	6.30
Insoluble matter,	36.30
Water,	0.40
	100.00

Limestone from lower band on river road, six miles above Delaware Water Gap. Color grey; coarse, sparry, crystalline; fracture irregular, angular.

Composition in 100 *parts:*

Carbonate of lime, - - - - - -	81.95
Carbonate of magnesia, - - - - -	none
Alumina and oxide of iron, - - -	3.10
Insoluble matter, - - - - - -	14.60
Water, - - - - - - - -	0.50
Excess, - - - - - - - -	0.15
	100.00

Limestones from F. VIII.

Limestone from McMickle's creek, Stroudsburg. Color dull slate blue; moderately compact; grain fine, sub-crystalline; fracture conchoidal, angles sharp.

Composition in 100 *parts:*

Carbonate of lime, - - - - - -	83.30
Carbonate of magnesia, - - - - -	7.22
Alumina and oxide of iron, - - -	traces
Insoluble matter, - - - - - -	9.98
Water, - - - - - - - -	0.50
	100.00

Limestone from Karthaus, Clearfield county. Color blue; compact; fracture slightly conchoidal, angular.

Composition in 100 *parts:*

Carbonate of lime, - - - - - -	48.89
Carbonate of magnesia, - - - - -	2.03
Alumina and oxide of iron, - - -	5.18
Insoluble matter, - - - - - -	43 18
Water, - - - - - - - -	0.72
	100.00

Limestone from Shamokin Coal Company's lands, Northumberland county. Color dull brownish grey; texture somewhat slaty; grain moderately fine; weathered surface ochreous brown; fracture somewhat conchoidal.

Composition in 100 *parts:*

Carbonate of lime,	71.32
Carbonate of magnesia,	7.48
Alumina and oxide of iron,	2.80
Insoluble matter,	17.80
Water and organic matter,	0.60
	100.00

Limestones from Formation XIII.

Limestone from John Weines's, Muddy Creek township, Butler county. Dove colored; texture compact, close grained; fracture smooth and slightly conchoidal; surface fossiliferous, containing encrinal impressions.

Composition in 100 *parts:*

Carbonate of lime,	96.10
Carbonate of magnesia,	none
Alumina and oxide of iron,	1.30
Insoluble matter,	2.30
Water,	0.30
	100.00

Limestone from Madison furnace, used as a flux, Clarion county. General character and appearance same as the above.

Composition in 100 *parts:*

Carbonate of lime,	96.90
Carbonate of magnesia,	none
Alumina and oxide of iron,	0.50
Insoluble matter,	2.30
Water,	0.30
	100.00

Limestone from upper bed, on Sugar creek, Armstrong county. Color bluish grey; compact, in parts semi-crystalline; fracture somewhat conchoidal.

Composition in 100 *parts:*

Carbonate of lime, - - - - - -	94.00
Carbonate of magnesia, - - - -	none
Alumina and per oxide of iron, - - -	1.30
Insoluble matter, - - - - - -	4.30
Water, - - - - - - - -	0.40
	100.00

Limestone from Rockland furnace, Venango county. Color greyish drab; texture compact, fine grained; fracture conchoidal; faint traces of fossils.

Composition in 100 *parts:*

Carbonate of lime, - - - - - -	84.25
Carbonate of magnesia, - - - - -	none
Alumina and per oxide of iron, - - - -	1.00
Insoluble matter, - - - - - - -	12.80
Water, - - - - - - - -	0.45
Loss - - - - - - - - -	1.50
	100.00

From the composition of some of the above limestones when compared with those known to furnish hydraulic cements, there is every reason to believe that they are well adapted to this purpose.

The recent discovery made by my brother, Professor William B. Rogers, that *most of the older limestones of the U. S. abound in magnesia;* and that these magnesian limestones *yield a lime capable of hardening under water*, is an additional inducement for undertaking an extensive chemical analysis of our calcareous rocks. For the purpose of exhibiting the close identity in composition between many of our magnesian limestones and those of Virginia and elsewhere, which have been found to be eminently hydraulic, I have transcribed a few analyses from the Report on the Geological Survey of Virginia for the year 1838.

Limestone from near Sheppardstown, on the Potomac, Virginia; extensively manufactured into cement.

Composition in 100 *parts:*

Carbonate of lime,	55.80
Carbonate of magnesia,	39.20
Alumina and oxide of iron,	1.50
Silica and insoluble matter,	2.50
Water,	0.40
Loss,	0.60
	100.00

Limestone from the Natural bridge and banks of Cedar creek, Virginia. Makes a good hydraulic cement.

Composition in 100 *parts:*

Carbonate of lime,	53.23
Carbonate of magnesia,	41.00
Alumina and oxide of iron,	0.80
Insoluble matter,	2,80
Water,	0.40
Loss,	1.77
	100.00

Limestone from Formation II., New York, extensively burnt for cement.

Composition in 100 *parts:*

Carbonate of lime,	48.20
Carbonate of magnesia,	35.76
Alumina and oxide of iron,	1.20
Insoluble matter,	12.10
Water,	2.73
Loss,	0,01
	100.00

Limestone from Louisville, Kentucky, said to make a good cement.

Composition in 100 *parts:*

Carbonate of lime,	55.03
Carbonate of magnesia,	24.16
Alumina and oxide of iron,	2.60
Insoluble matter,	15.30
Water,	1.20
Loss,	1.71
	100.00

The valuable property of magnesian limestones of making a cement which hardens under water, was first hinted at by M. Vicat, of France, but its dependence on the magnesia was not shewn until the analyses and experiments of my brother conclusively established the fact.

All which is respectfully submitted.

HENRY D. ROGERS.

Philadelphia, *February* 1, 1841.

GLOSSARY

OF

GEOLOGICAL AND OTHER SCIENTIFIC TERMS EMPLOYED IN THIS REPORT.

EXTRACTED FROM LYELL'S PRINCIPLES OF GEOLOGY.

Alluvium. Earth, sand, gravel, stones, and other transported matter which has been washed away and thrown down by rivers, floods, or other causes, upon land not *permanently* submerged beneath the waters of lakes or seas. *Etym. alluo,* to wash upon.

Anticlinal Axis. If a range of hills, or valley, be composed of strata, which on the two sides dip in opposite directions, the imaginary line that lies between them, towards which the strata on each side rise, is called the anticlinal axis. In a row of houses with steep roofs facing the south, the slates represent inclined strata dipping north and south, and the ridge is an east and west anticlinal axis.

Argillaceous. Clayey, composed of clay. *Etym. argilla,* clay.

Bitumen. Mineral pitch, of which the tar-like substance which is often seen to ooze out of the Newcastle coal when on the fire, and which makes it cake, is a good example. *Etym. bitumen,* pitch.

Bituminous Shale. An argillaceous shale, much impregnated with bitumen, which is very common in the coal measures.

Calcareous Rock. Limestone. *Etym. calx,* lime.

Calcareous Spar. Crystallized carbonate of lime.

Carbon. An undecomposed inflammable substance, one of the simple elementary bodies. Charcoal is almost entirely composed of it. *Etym. carbo,* coal.

Carbonate of Lime. Lime combines with great avidity with carbonic acid, a gaseous acid only obtained fluid when united with water, —and all combinations of it with other substances are called *Carbonates.* All limestones are carbonates of lime, and quick lime is obtained by driving off the carbonic acid by heat.

Carboniferous. A term usually applied, in a technical sense, to an ancient group of secondary strata, but any bed containing coal may be said to be carboniferous. *Etym. carbo,* coal, and *fero,* to bear.

Chert. A siliceous mineral, nearly allied to calcedony and flint, but less homogeneous and simple in texture. A gradual passage from chert to limestone is not uncommon.

Coal Formation. This term is generally understood to mean the same as the Coal Measures. There are, however, "coal formations" in all the geological periods, wherever any of the varieties of coal form a principal constituent part of a group of strata.

Conformable. When the planes of one set of strata are generally parallel to those of another set which are in contact, they are said to be conformable.

Conglomerate or Puddingstone. Rounded water-worn fragments of rock, or pebbles, cemented together by another mineral substance, which may be of a siliceous, calcareous, or argillaceous nature. *Etym. con,* together, *glomero,* to heap.

Crop Out. A miner's or mineral surveyor's term, to express the rising up or exposure at the surface of a stratum or series of strata.

Crystalline. The internal texture which regular crystals exhibit when broken, or a confused assemblage of ill-defined crystals. Loaf-sugar and statuary-marble have a *crystalline* texture.—Sugar-candy and calcareous spar are crystallized.

Denudation. The carrying away by the action of running water of a portion of the solid materials of the land, by which inferior rocks are laid bare. *Etym. denudo,* to lay bare.

Diluvium. Those accumulations of gravel and loose materials which, by some geologists, are said to have been produced by the action of a diluvial wave or deluge sweeping over the surface of the earth. *Etym. diluvium,* deluge.

Dip. When a stratum does not lie horizontally, but is inclined, the point of the compass towards which it sinks is called the dip of the stratum, and the angle it makes with the horizon is called the angle of dip or inclination.

Encrini. (plural of encrinus) Marine animal bodies, having a long jointed stem, the joints somewhat resembling small buttons with a central perforation. These abound in the lower secondary rocks.

Fault, in the language of miners, is the sudden interruption of the continuity of strata in the same plane, accompanied by a crack or fissure, varying in width from a mere line to several feet, which is generally filled with broken stones, clay, &c.

Ferruginous Anything containing iron. *Etym. Ferrum*, iron.

Formation. A group, whether of alluvial deposits, sedimentary strata, or igneous rocks, referred to a common origin or period.

Fossil. All minerals used to be called fossils, but geologists now use the word only to express the remains of animals and plants found buried in the earth. *Etym. fossilis*, any thing that may be dug out of the earth.

Gneiss. A stratified primary rock, composed of the same materials as granite, but having usually a larger proportion of mica, and a laminated texture. The word is a German miner's term.

Gypsum, a mineral composed of lime and sulphuric acid, hence called also *sulphate* of *lime*. Plaster and stucco are obtained by exposing gypsum to a strong heat. It is found so abundantly near Paris, that Plaster of Paris, is a common term in this country for the white powder of which casts are made.

Laminæ. Latin for plates; used in geology, for the smaller layers of which a stratum is frequently composed.

Mica. A simple mineral, having a shining silvery surface, and capable of being split into very thin elastic leaves or scales. It is often called *talc* in common life, but mineralogists apply the term talc to a different mineral. The brilliant scales in granite are mica. *Etym. mico*, to shine.

Organic Remains. The remains of animals and plants (*organized* bodies) found in a fossil state.

Oxide. The combination of a metal with oxygen; rust is oxide of iron.

Oxygen. One of the constituent parts of the air or the atmosphere; that part which supports life. For a further explanation of the word, consult elementary works on chemistry.

Producta. An extinct genus of fossil bivalve shells, occurring only in the older secondary rocks. It is closely allied to the living genus Terebratula.

Pyrites. (Iron.) A compound of sulphur and iron, found usually in yellow shining crystals like brass, and in almost every rock stratified and unstratified. The shining metallic bodies, so often seen in common roofing slate, are a familiar example of the mineral.

Quartz. A German provincial term, universally adopted in scientific language, for a simple mineral composed of pure silex, or earth of flints: rock-crystal is an example.

Sandstone. Any stone which is composed of an agglutination of grains of sand, whether calcareous, siliceous, or of any other mineral nature.

Seams. Thin layers which separate two strata of greater magnitude.

Secondary Strata. An extensive series of the stratified rocks which compose the crust of the globe, with certain characters in common, which distinguish them from another series below them, called *primary*, and from a third series above them called *tertiary*.

Shale. A provincial term, adopted by geologists, to express an indurated slaty clay. *Etym.* German *schalen*, to peel, to split.

[illegible]gle. The loose and completely water-worn gravel on the sea shore.

Silex or Silica. The name of one of the pure earths, being the Latin word for *flint*, which is wholly composed of that earth.

Siliceous. Of or belonging to the earth of flint. *Etym. silex.* which see. A siliceous rock is one mainly composed of silex.

Stalactite. When water holding lime in solution deposits it as it drops from the roof of a cavern, long rods of stone hang down like icicles, and these are called *stalactites.*

Stalagmite. When water holding lime in solution drops on the floor of a cavern, the water evaporating leaves a crust composed of layers of limestone; such a crust is called *stalagmite*, in opposition to *stalactite*, which see.

Strata, Stratum. When several rocks lie like the leaves of a book, one upon another, each individual forms a *stratum*;—strata is the plural of the word. *Etym. stratum*, part of a Latin verb, signifying to strew or lay out.

Strike. The direction or line of bearing of strata, which is always at right angles to their prevailing dip.

Synclinal Axis. When the strata dip in opposite directions *towards* a common central imaginary line, it is called a synclinal line or axis.

Thin out. When a stratum, in the course of its prolongation in any direction, becomes gradually less in thickness, the two surfaces approach nearer and nearer; and when at last they meet, the stratum is said to thin out, or disappear.

Zoophytes. Corals, sponges, and other aquatic animals allied to them, so called because, while they are the habitation of animals, they are fixed to the ground, and have the forms of plants. From two Greek words signifying animal and plant.

SIXTH ANNUAL REPORT

ON THE

GEOLOGICAL SURVEY

OF

PENNSYLVANIA.

BY HENRY D. ROGERS,
STATE GEOLOGIST.

Read in the House of Representatives, Feb. 9, 1842.

HARRISBURG:
HENLOCK & BRATTON, PRINTERS.
1842.

COMMUNICATION.

Office of the Secretary of the Commonwealth,
February 9, 1842.

To the Speaker of the
House of Representatives of Pennsylvania:

Sir:—In compliance with the third section of the act of 29th March, 1836, entitled, "An Act to provide for a Geological and Mineralogical Survey of the State," I herewith transmit to you the Sixth Annual Report on the Geological Survey of Pennsylvania, as made to me by Henry D. Rogers, Esq., State Geologist.

From the limited examination which I have made of this report, it is manifest that the work of that officer is yet incomplete, and further appropriations are requisite to carry into full effect the original design of the Legislature, in giving to our citizens, and to the world, a complete knowledge of the vast mineral resources of the State. The suggestions made by that gentleman, relative to the publication of his final report, and furnishing maps for the purpose of exhibiting clearly the result of his geological labors, cannot fail to arrest the attention of the Legislature.

I am conscious, that large sums of money have been expended by the State, in prosecuting these surveys, and it becomes a subject of serious consideration, whether, after so much money has been spent, it would not be sound policy, and in accordance with the wishes of the people of the State, to furnish such a sum as will be necessary to render the work complete, and in order that the State may enjoy all the benefits which were anticipated when the enterprize was first begun.

A large amount of valuable information will necessarily be communicated to the public, when Mr. Rogers gives us the view of all his labors, which cannot fail to be useful and highly beneficial to the Commonwealth.

A. V. PARSONS,
Secretary of the Commonwealth.

REPORT.

To the Secretary of the Commonwealth:

SIR:—I beg leave, in compliance with the law, to transmit to the Legislature the following Report of the progress of the Geological Survey of the State, during the past year.

In my former annual communications, I submitted some detached portions of the geological and chemical results of the Survey, which were, occasionally, minute. These annual sketches seemed called for by the public wish, and were appropriate enough, so long as a considerable time yet remained to the completion of the work. But now, that the survey is nearly finished, the inducement to make a partial publication of details has ceased, and the large accumulation of materials, renders it imperative upon me to give the whole of my time to the laborious task of preparing my final report. The unavoidable omission, for the present, of minute descriptions, is the less to be regretted since we are under the necessity of postponing the publication of the maps and other drawings so essential to the proper illustration of whatever is local, until the appearance of the final report. To bring forward now, the partially finished fragments of the work, when another year will, probably, suffice to mature the whole and accompany it by all the requisite illustrative drawings, would be to incur a needless present expense and an ultimate delay. The interests of the survey will, therefore, be best consulted if I confine myself, on this occasion, to a brief notice of our investigations for the past year, and to a general account of the present posture of the work, with some suggestions for bringing its results speedily and in the most useful form before the public.

The general description of our geology, which will form my concluding labour, and which alone can convey a just idea of the economical importance and scientific value of the survey, I shall zealously endeavor to complete in time to present to the Legislature at its next session. Meanwhile, the sketch I am about to offer, of the plan and scope of my final report, will enable the Legislature to perceive the necessity of granting me the time I ask, and of devising the best method of bringing my results, with the least delay, before the public.

Operations of the Geological Corps during the past year.

The unfinished explorations of previous seasons were resumed in May last, as soon as the Legislature authorized the prosecution and completion of the survey. The delay of a few weeks in taking the field, while waiting for legislative action, proved a somewhat serious inconvenience, as it compelled me to procure additional aid with the fund provided for incidental expenses, and forced some of my corps to continue the campaign until the close of November, when the coming on of actual winter put a bar to all further researches.

Assigning to my assistants, under the present reduced organization of the corps, the examination of those districts respectively with which they had already become partially familiar, Mr. Alexander M'Kinley undertook the completion of his researches in the coal fields of Broad Top ~~mountain and the~~ Wyoming valley, while Mr. Harvey B. Holl, Dr. R. M. S. Jackson, Mr. Peter Lesley, and Mr. ~~Martin H. Boye,~~ resumed the exploration of the great bituminous coal region, north-west of the Allegheny mountain. In the month of August, Mr. Lesley transferred his attention to parts of the anthracite district, where he spent the remainder of the season collecting materials for perfecting the geological map of that intricate region. A little later, Mr. Holl, after accomplishing his duties in the west, entered upon some special researches in the country bordering the Juniata river, from its source to the Susquehanna. Throughout the year, Dr. Robert E. Rogers, my chemical assistant, was engaged in the labors of the laboratory.

In the rather intricate and obscure coal field of the Broad Top mountain, in Bedford and Huntingdon, several weeks were passed in an earnest endeavor to unfold its structure and trace the coal. Several persons were employed at intervals in digging and mining, with a view to identify the various coal seams, at the localities which promised the best results. Though during this and previous season's researches we had gained a tolerable insight into the obscure stratification of this district, we are now convinced, that to unravel entirely all its local complexities would require an amount of time and an [illegible]ed system of mining, not compatible with the resources, nor indeed with the plan of the survey. Enough of its detailed geology will, I trust, be made known, through my final report, to accomplish one main practical object, that of aiding, materially, the future explorations of persons interested in the soil, so as to prevent much useless waste of capital.

The long and well defined valley of the Wyoming and Lackawanna coal basin, extending from Carbondale to Beachgrove, was in certain districts minutely examined during the latter part of the summer and autumn, our limited time and means alone preventing the thorough exploration of a few unfinished neighborhoods. From its western termination, as far eastward as the mouth of the Lackawanna, the valley was studied with very considerable minuteness. The comparatively more simple geology of the portion occupied by the Lackawanna had been examined with some care, in a former season, when we collected a series of transverse sections of the strata, with a view to explain its interesting local features and resources.

The Wyoming valley, as distinguished from the Lackawanna division of the basin, discloses a structure of very perplexing intricacy. Its thick mass of coal measures, far from lying in the form of a simple trough, contains a series of anticlinal axes, and a succession of short and abrupt foldings of the strata, which give to many parts of it a very disturbed character. From Nanticoke to the western extremity of the basin, this structure is more especially predominant. Though it causes considerable difficulty in identifying and tracing particular beds of coal, we succeeded in establishing some important general facts respecting the direction of the lines of disturbance, a knowledge of which will render the future discovery of any particular seams of coal, or other strata, comparatively certain. One leading and important general determination relates to the curious parallelism of anticlinal axes with the southern boundary of the valley, locally called the Little mountain. These lines of elevation are consequently oblique to the Nanticoke or River mountain on the north.

A complete vertical section of all the coal measures in this basin, from the underlying conglomerate rock to the highest coal seam, is still a desideratum. Want of time, rather than the complexity of the stratification, to which we now possess a sufficient clue, prevented our entire success in collecting the requisite materials. Enough has, however, been established by a comparison and union of the numerous local sections examined, to make known the existence of a greater number of coal seams in the basin than had previously been suspected to exist. A tolerably full section was measured along the railroad of the Wyoming Coal Company, where we ascertained the relative distances and thicknesses of nine seams of coal. The thickest coal-bed of the basin lies to the south of any seam yet intersected in the cuttings of this railroad. Beneath it, but still above the conglomerate, there are at least three other beds of a size fit to work. Higher in the series than that which is styled the "Slope Vein," we have ascertained several others to exist, some of which will probably prove important.

The lowest coal seam in the basin, reposing at Nanticoke, nearly on the conglomerate rock, was identified at many localities, and carefully traced westward to Beach's mine at the river. It is mined by Col. Lee, at Nanticoke, and has been opened by Mr. H. Colt in the "Hogback," and at the foot of the River mountain. It is also wrought by Mr. Harvey, who has, besides, opened it near the top of the mountain. At Plymouth, the mines of Thomas, of Reynolds, and of F. Smith, are established in this coal-bed. North-eastward of Plymouth it seems to decrease in thickness. The lowest of the two beds, opened in the "Hollow" by Mr. Raub, we are disposed to regard as also identical with this seam.

The thickest mass of coal in the whole basin is the great bed of the Baltimore Company's mine, which, in some places, measures thirty-two feet, embracing, of course, several thin bands of included slate. This is not the same seam as that wrought by Lee and Harvey, its position being considerably higher in the series. The bed seems to have its greatest thickness at the large mine of the Baltimore Company, and to decline in size as it extends to the south-west. Many openings have been made into this bed in the Little mountain. It is supposed to be this seam which is wrought by Hurbut and by Stivers. That wrought by Mr. Holland in Nescopeck township, is certainly the same.

The wide bituminous coal region, north-west of the Allegheny mountain, claimed the attention of the other members of my corps, and a large share of my own, for the greater part of the season. In exploring the unfinished portions of this district, we succeeded, combining and applying the results of previous seasons, in unfolding its grand yet simple features of stratification, to an extent far surpassing my most sanguine anticipations. To Mr. Lesley was assigned the duty of examining the numerous detached small coal fields, scattered over the northern counties of the State, from the North Branch of the Susquehanna to Jefferson county. By giving strict attention to the range and distribution of the strata beneath the coal, and to the manner in which they rise to the surface along a series of parallel anticlinal belts, the various insulated patches of the coal formation were successfully traced, and found to be distributed with an unexpected degree of symmetry, in a succession of singularly regular troughs or basins. Besides determining, with tolerable accuracy, the area occupied by each local tract of coal measures, we were enabled, in most instances, to identify particular seams of coal and beds of iron ore, and so to establish their characters and position as to make it easy hereafter for individuals to trace them. When we consider the yet wilderness condition of a large portion of this district, and the consequent fewness of good exposures of the rocks, we can ascribe our success, such as it has been, only to the remarkable persistency of the strata. To describe the geology of these northern counties, either intelligibly or with profitable minuteness, would require a constant reference to our yet unfinished map and sections. I shall, therefore, postpone all details, until I can present them in their proper connection in my final report.

To Mr. Holl and Mr. Boye was entrusted the duty of carefully unfolding the stratification of the large and productive coal region lying to the west and south-west of the eastern line of Jefferson county, as far as the Ohio line on the one side, and the valley of the Kiskiminetas on the other. Guided by the knowledge of the strata previously obtained, Mr. Holl applied himself to tracing out in detail the various coal seams, limestones, beds of iron ore, and the other deposits of that large tract of the coal measures which ranges from the western part of M'Kean county, through Venango, Clarion, Mercer, Butler, Beaver, and part of Armstrong. This district constitutes a regular and natural basin, widening and deepening towards the south-west. It is the sixth and last trough of our western coal formation, counting north-westward from the Allegheny mountain. On the N. W. it is definitely limited by a belt of country, composed of the great coal conglomerate which ranges to the south-west out of Warren, through Venango, into Mercer. On the S. E. it is bounded by a well marked anticlinal axis, passing from near Smethport in an almost straight line towards Pittsburg.

The detailed examinations made in this basin during the past year have now rendered it certain, that the limestones and many of the coal seams are continuous over very extensive areas, though the individual beds frequently change much their thickness and external aspect. The included sandstones, slates, and other more mechanically formed rocks, display, however, incessant variations of thickness and composition, which make it impossible to trace these individually, over any very wide extent of country. Thus, two seams of coal, in some places separated by sixty feet of strata, will at other points lie within twenty feet of each other.

Viewing the whole of the 700 or 800 feet of coal measures, which occupy this trough north of the Ohio river, we find eight widely distributed coal seams, besides several smaller local ones. Those which are important for their dimensions, I shall designate for the sake of present convenience, by their position, counting from the lowest upwards. The four lowest beds, which are included between the first and second thick sandstones, and which are developed, chiefly, in Mercer, Venango and Warren, are neither as continuous nor for the most part as thick, as the beds above them. One which occurs at the town of Mercer and at Sandy Lake, possesses, however, a thickness of from four to six feet. Accompanying these lower coals in Mercer county, we find the lowest bed of limestone any where met with in our western coal measures. Of the *fifth*, *sixth*, *seventh*, and *eighth* coal seams, which are much the most continuous and uniformly valuable, the *fifth* is the main bed, seen at Fallston, New Castle, Kittanning, Murvinsville, and in Irwin and Scrubgrass townships, in Venango. The *seventh* is the most important bed on the Allegheny river about Sugar creek and on the Red bank; while the *eighth* is the chief seam at the town of Butler. This last, which is a very valuable bed, accompanies the preceding, though at a greater elevation in the hills, in the vicinity of Sugar creek and Kittanning, and in the neighbourhood of Freeport. These several coal-seams, together with the limestones, have been regularly traced by their outcrops, and their positions recorded on the map, while the various circumstances of their thickness, change of distance and accompanying strata, have been carefully recorded.

A portion of the season was devoted by Mr. Holl to similar researches, in parts of the three parallel basins, situated next to the eastward of the large one just spoken of. The beds of coal and limestone of these troughs, have now for the most part been identified with those in the westernmost basin, though their accidents of thickness and quality are often different. Thus the *fifth* coal-seam, where it occurs about twelve miles east of Brookville, measures between eight and nine feet. The *seventh* bed occurs in considerable size at Punxatawny, and it is ten feet thick between the Red bank and Mahoning, on the road from Kittanning to Brookville. The *eighth* is the most available seam in the neighborhoods of Curwensville and Mount Pleasant. Throughout all this wide range of country, this last coal-bed is accompanied by an underlying limestone, the position of which is well seen around Freeport.

To Mr. Boye I confided the task of examining, in detail, those districts of Armstrong and Indiana, which lie between the Kiskiminetas or Conemaugh on the south, the Big Mahoning on the north, the Allegheny river on the west, and the range of the Chesnut ridge on the east. The valleys of the Conemaugh and Kiskiminetas cutting deep into the strata, afforded an excellent opportunity for determining the position of several of the parallel troughs into which the coal measures of this region are distributed, and for instituting accurate measurements at various points, with a view to the identification and tracing of the special beds of coal, limestone, iron ore and other useful strata. By using the data thus furnished, the difficulties which had hitherto retarded the working out of the geology of this district, caused mainly by the variability of the slates and sandstones, was successfully overcome, and a sufficiently minute knowledge gained of the range and distribution of every important bed in the series.

Though a considerable share of attention had been given during former seasons to the counties south of the Conemaugh and the Ohio, the systematic tracing of their coal measures was still incomplete, more especially throughout parts of Westmoreland and Fayette. I therefore assigned to Dr. Jackson, already familiar with this region, the duty of making a methodical survey of all the unfinished neighborhoods, as far as our time and resources would permit, and in order to expedite the work, he was furnished, in the latter two months of the season, with an adjunct in Mr. Townsend Ward. The same methods of investigation, so successfully applied in other districts of our great western coal field, were adopted here. The principal transverse valleys were carefully searched for natural exposures, and numerous measurements instituted and data collected, for identifying and tracing the individual beds, and for coloring in their outcrops upon the geological map. Though cramped for time, we have succeeded in tracing with all the minuteness desirable, the beautifully symmetrical geology of this productive region.

The portion of this country most minutely examined, is that which lies between the western base of Chesnut ridge and the Monongahela river, and between the Conemaugh and the Virginia line. Some unfinished researches in the valley east of the mountain, were also resumed and completed. The strata brought under investigation in the first and larger tract, commencing below with the bottom of the coal measures, which repose on the western flank of the mountain, and take in the whole of the series as high as about 200 feet above the Pittsburg coal seam.

This thickness includes several coal seams, lying above the great Pittsburg bed, which occur in the highest hills of the middle or deepest part of the trough which is next west of the mountain. Between the mountain, here called Chesnut Ridge, and the Monongahela river, there are two parallel anticlinal axes which throw these western coal measures into three closely united troughs. The most eastern line of elevation crosses the Conemaugh about two miles west of Blairsville, and ranges to the Virginia line, preserving an average distance of about five miles from the western base of the mountain. In some parts of its course this axis imparts a decided feature to the topography; but elsewhere there is nothing in the contour of the surface merely, which would lead us to look for it. Approaching the southern line of the State the anticlinal arch begins to subside, allowing the lower coal measures, which a few miles further north have been entirely swept away from its summit, to sweep gently over it.

The second axis or arch crosses the Conemaugh about four miles above Saltsburg, and extends parallel to the former, preserving a distance of about five miles, to the west, until it terminates nearly one mile and a-half north of Sewickly creek. Here the arch flattens away, and its eastern dip gives place, at that stream, to a western one, thrown off from the first, and more continuous arch lying east. This second axis is usually indicated by a low belt of hills, the *soil* of which is much inferior to that in the adjoining troughs. Nearly continuous with this axis, but situated a little to the west of what would be its regular prolongation, there rises further to the southwest, another low anticlinal arch, which elevates the rocks in the vicinity of Brownsville. Between the mountain, therefore, and the first arch or axis west of it, we have a long and narrow trough, of the coal formation, extending the whole distance from the Conemaugh to Virginia; and west of this, or between the first axis and the two other nearly continuous ones, last described, there is another parallel and similar basin, ranging the same distance. West of the Saltsburg and Brownsville axis is the deeper and much broader basin of the counties of Washington, Allegheny and Greene, traversed by a few low undulations not of length and force enough to divide the general one into subordinate troughs, like those in the district east of the Monongahela.

The lower strata of the coal measures, those which underlie the large Pittsburg seam, consist of sandstones, limestones, slates and thin beds of coal. They lean against the western slope of the

Chesnut Ridge, at the base of which the strata next beneath the large coal seam have been swept away along a range of depressions disuniting the outcrop of this main seam from the flank of the mountain.

In this portion of the formation there are four beds of coal, and in two or three localities two other very thin ones, which are not apparently persistent. Only two of the four beds are sufficiently thick to be wrought, the rest measuring from six inches to twenty inches or sometimes two feet. The two available beds vary in thickness from eighteen inches to five feet, the uppermost being commonly the thickest. They are situated low in the series, the inferior one holding a position from twenty to seventy feet above the great coal conglomerate, and the other larger bed lying from 50 to 150 feet above the first. They are generally exposed in the transverse ravines occupied by the streams which cut the flank and base of the mountain, and are associated with the first thick sandstones overlying the conglomerate, in a chain of elevation which blends with the lower slopes of the ridge. They are likewise brought above the drainage of the general plain west of the mountain, in the anticlinal arches, already described, where they are exposed in the little valleys that intersect these axes. They are thus seen on the Conemaugh above Saltsburg and on the Loyalhanna.— On the Sewickly, likewise, both of these beds are exposed, the uppermost being mined for fuel at the saltworks of that stream. These coal beds are again intersectcd by the valleys of Jacob's creek, of the Youghiogheny and of the Redstone.

The first trough or basin lying west of the mountain, includes the large Pittsburg seam throughout its whole extent. This superb bed occupies the middle of the basin and appears along two lines of outcrop, which range from half a mile to two and a-half miles asunder. In some neighborhoods the bed, as it dips into the middle of the trough, descends to a considerable depth below the lowest water course; while in other places the bottom of the basin which it forms does not reach the water level. A short distance west of the National turnpike this seam arches over the first anticlinal axis, along the central tracts of which it is found high in the hills. In this position it continues into Virginia, where, on the Cheat river, it holds a position probably 200 feet above the level of the stream. The anticlinal arch at this place is very gentle.

This large seam also occupies a portion of the second trough, where it lies in the shape of a long narrow canoe, one end terminating a few miles north of the town of New Alexandria, and the other, three miles southwest of Greensburg. The length of the so called canoe is about fifteen miles, and its greatest breadth a little less than two miles.—South of the point where the second arch flattens away, the outcrop of the Pittsburg seam, which lies west of the axis, sweeps eastward round its termination, and takes a corresponding place on the western side of the first and more continuous arch. It continues in this position to the point already mentioned about two miles southwest of the National turnpike, where it folds over this first or eastern arch and blends with that portion of the seam which fills the first trough or basin at the foot of the mountain.

Above this great coal seam there occur several other lesser beds, and an important mass of limestone, which constitutes one of the most persistent of the strata, in the western coal measures. The first coal over the Pittsburg bed, of any noticeable thickness, is very thin, and in the northern part of the district is sometimes altogether wanting. Advancing southwards to the Sewickly, we find it, however, as thick as four and a-half feet, and composed of very good coal.—Here it is about thirty-five feet above the great seam, and only a short space below the large mass of limestone. Further still to the southwest it somewhat augments in size, and has been wrought at several places. At Evans' mill it is five feet thick and supplies an admirable fuel. Near Uniontown it is separated from the great seam by eighty-five feet of other strata.

The ~~great bed of limestone seems to increase~~ in thickness as it extends to the south-west. Above this limestone, there is a seam of coal which varies in size from eighteen inches to three feet. This is opened at Uniontown, and at several places further to the south-west. Higher still in the series, two other beds occur; but the next seam of importance lies above these again, being confined to the very highest hills in the middle of the first trough. It is opened in several places in Westmoreland and Fayette, and varies from four to six feet in thickness. It was traced and exposed by us at a number of points, where its existence was not before suspected. From the usual high position of this seam in the hills, it is apt to be destitute of a good roof; but wherever it is sufficiently covered, the quality of the coal is excellent. This is the highest valuable coal bed of the district. Besides these now enumerated, several lesser seams, which are only locally important, were examined and their positions in the series ascertained.

The several coal-seams here briefly mentioned, were regularly traced by their outcrops, and their distances and dimensions established at a number of standard localities. Other data were also collected, by means of which their position, and that of other useful beds, can readily be made known for every part of the district, through a series of transverse and vertical sections, intended to accompany my final report and map.

In the chemical department of the survey, an extensive series of minute and detailed analyses has been performed by my chemical assistant, Dr. Robert E. Rogers. These exhibit the composition and properties of a number of our ores, coals, cements, fluxes, &c., not previously examined, and embrace a variety of interesting results, both local and general. The final comparison of the chemical facts now collected by us, will, it is believed, lead to some general inferences of real economical value and scientific interest. Several trains of chemical research being still in progress, the details and generalizations which they suggest, will be deferred until they can be introduced in a properly matured form in the final report.

From the above sketch of our operations during the past season, it will be seen that, with the exception of a few local tracts unavoidably omitted, through want of time, our researches have included nearly every district of any geological importance, the exploration of which was before unfinished. Should the Legislature authorize my entering at once upon the construction of my final report, I shall probably find opportunity for revising certain neighborhoods, before my final description of their geology goes to press.

Of the Final Report and the Illustrations to accompany it.

The systematic operations in the field having been brought to a successful termination, my principal remaining duty under the law providing for the survey, relates to the preparation of the final report, designed to include all the results, both general and local, of our explorations. It is my intention to enter upon this, which will form the crowning labor of the survey, as soon as I shall have done arranging, in conjunction with my assistants, the large mass of observations made during the past season, a duty which will probably engross me for the remainder of the winter. While I avow my anxiety to urge on this concluding work with all possible diligence, I feel called upon in justice to the interests of the survey, and in fairness to myself, to exhibit to the Legislature the arduous magnitude of the task before me, resulting from the rich abundance of the materials gathered by a large corps, during six active years. Only the few who chance to be familiar with this species of authorship, can understand what toil and time it requires, to analyse and clearly display all the details and generalizations, essential to so vast a theme. Nor indeed can even they, if they do not take into view the wide extent of the area explored, and its unsurpassed mineral wealth. Not only is Pennsylvania one of the largest regions ever yet brought under systematic geological investigation, but it is for its size by much the richest territory known, in point of available native wealth. Independently of this, it possesses remarkable intricacy of structure. Some conjecture may therefore be formed of the fulness and complexity of the details which it will fall to my task to methodize, condense and elucidate.

That the Legislature may perceive the justice of these remarks, and the propriety of allowing me the time and means necessary to the preparation of my final report, I will here subjoin a brief general sketch of the plan and scope of the work, and its illustrations. In offering this outline, I would most respectfully suggest the expediency of authorizing the engraving of such portions of the illustrations, as may be soonest in readiness, before the meeting of another Legislature. Unless the finished portions of the maps and drawings be allowed to go to press without waiting for the rest, it will be impossible, it seems to me, to accomplish the publication of the whole, before another annual session of the Legislature passes by.

Plan of the Final Report.

The final report, the design of which is to embrace both the general and local results of the survey, ought to comprise, I conceive, two distinct treatises, the one general, the other detailed. The propriety of this will sufficiently appear, when we reflect upon the nature of the observations which belong to a thorough geological examination of a territory so extensive and intricate as Pennsylvania. The whole assemblage of these observations will be found to include on the one hand a vast body of local details, highly instructive to the inhabitants of the districts to which they relate, but not valuable to others; and to lead, on the other hand, to numerous general conclusions and scientific results, mainly interesting to the general reader. The large mass of special details, may be regarded in the light of the scaffolding to the general edifice of our geology; but scaffolding which itself is locally valuable and which it does not become us to reject. To unite in the same pages with the general description, the whole vast body of particular observations, or the lesser results upon which the larger generalizations depend, would be to load down the work with a tiresome, unintelligible mass of geographical allusions, acceptable neither to the resident nor the distant reader. As, however, this neighborhood geology is often of the utmost *local* value, I propose to embody it in a separate division of the work, in as condensed a shape as will be consistent with the requisite clearness and fulness of detail. By this means, I hope to render it easier for all classes of readers to procure the kind of information they are in pursuit of.

Whilst the general treatise, entire in itself, will make known to the man of science or the general enquirer whatever relates to the composition, ancient origin, and present wonderful and beautiful structure of our formations; and whilst it will show to the capitalist at home and abroad, the position, mode of tracing, and surpassing abundance of our mineral wealth, the other treatise, to which the first will prove a useful key, consisting of the local and economical details, will fulfil a separate object as a work of reference, which can be resorted to for data, for either practical or scientific purposes, and by the owners of the soil, for knowledge of their local resources.

The general treatise will contain a systematic classification and nomenclature of all the formations comprised within the State. It will include a general description of each formation, embracing its prevailing composition, its whole range and distribution, and the changes of thickness and aspect which it undergoes. To this will be added whatever relates to its organic remains and imbedded minerals. The organic remains will deserve to be carefully discussed, for the curious interest which attaches to them as one index to the circumstances under which the strata were originally formed, and for their usefulness in furnishing the best guide which we possess in many cases, to the position of particular mineral layers or beds. The imbedded minerals will likewise be described in all their general relations. Their position in the strata, and the various circumstances connected with their origin, and the manner in which they may be traced, will here be dwelt on. Many curious and important facts connected with the gradual changes which the formations undergo, will also be stated. Among these are the progressive modifications in their thickness, the introduction of some beds and disappearance of others, and whatever relates to the variations in the distribution of their organic remains.

The geological *structure* of every district in the State will be, likewise, fully described. Under this head will be exhibited the manner in which many of the strata have been uplifted into more or less inclined positions, and brought to the surface either in long, straight, parallel belts, or in irregular winding ones, or lifted without inclination, and left in horizontal patches. In the same chapters I shall investigate whatever relates to the curious manner in which most of the strata have been formed into more or less closely compressed troughs and arches, synclinal and anticlinal axes, a full account of which alone, can furnish the key to the stratification and resources of at least four-fifths of our territory. While thus describing the axes of elevation and depression, I shall also give an account of the manner in which the rocks have been still more violently deranged by great faults or fractures which intersect them, and shall point to the principles upon which they are to be traced, either along the surface, or below the water level. While thus treating of the various important questions of structure, I shall present my views of the nature of the forces, by whose stupendous agency the ponderous masses that form our mountains have been pleated and folded like a pile of pliant cloth pressed edgewise.

At the same time that both the general and local divisions of the final report will be illustrated by frequent references to the geological maps, the general treatise will be specially accompanied by its own sections, tables, and explanatory drawings.

The other treatise descriptive of the more detailed and local geology, will exhibit the various formations in their minuter features and subdivisions. Following the order pursued in the general treatise, as to the arrangement of the several branches of the subject, it will deviate essentially in the manner of treating the individual formations. In the other part of the work each formation will be independently examined in all its modifications, and traced throughout its entire range; but in this division the arrangement will be a mixed geological and geographical one. The larger geological areas will be subdivided into lesser natural tracts and basins, the limits of which are generally controlled by the valleys and mountain ridges; so that the special geology and mineral resources of each smaller belt of country will be given separately, while all the formations included in it will still be viewed under their proper geological relations.

One principal aim of this division of the work being to present the economical, or more immediately practical results of the survey, I shall here dwell with ample detail upon all observations and deductions believed to have any useful bearings. In giving a minute account of the rocks of each belt of country, particular mention will be made of whatever relates to the discovery or tracing of any valuable imbedded or associated minerals. By the assistance of the maps and sections, the local range and underground position of all the strata will be fully explained, and a clue or index furnished, wherever we possess it, by which special beds or deposits may easily be recognized. The survey of the State having been mainly undertaken for these economical results, much attention has been devoted to this branch of the investigation. Every useful insulated observation, and especially every available practical rule calculated to assist in detecting or tracing any valuable deposit, whether derived from a comparison of measurements, from the aspect of the strata, from the nature of the fossils, or from the external configuration of the surface, will be specially recorded, and wherever it is necessary explained by resort to diagrams and drawings.

Among the details of an economical character will be included an extensive series of chemical analyses, intended to show the peculiar composition and comparative richness of nearly all the varieties of ores, coals, cements, limestones, and other valuable mineral substances. This portion of the work will contain, it is believed, information of much local interest to the citizens of the State. By pointing out the relative value and quality of particular beds and deposits, in connection with whatever features we find to be distinctive of their composition, a variety of suggestions or rules can be given, corroborated by experiment, for choosing and applying the kinds best suited to their special uses in the arts. Thus, I shall exhibit the results of some chemical researches, not yet completed, relating to variations in the composition of a number of our most widely distributed coal seams, showing the changes which the same beds undergo as they range from place to place, and the characteristic peculiarities of different beds in the same locality. Other similar series of comparative analyses will be presented in relation to the iron ores, cements, and other substances. Many instructive facts, tending to the permanent developement of our mineral wealth, will be thus imparted. But the full value of this very laborious branch of our researches can only be understood when the final report, with its tables and drawings, shall have been published, and the State Cabinet arranged in harmony with the plan and details of the book. Specimens of every valuable vein or layer will be exposed, indicating on their labels their chemical composition, and, therefore, their useful adaptations. The collection will, at the same time, show with what strata they are associated in nature.

Of the Geological Maps and Sections.

The law authorizing the Geological Survey makes it the duty of the State Geologist to represent, in appropriate colors upon the present State map, all the various formations and mineral strata. This important duty, the proper execution of which is indispensable to the clear elucidation of our geology and mineral resources, I have earnestly endeavored to perform, with all the fidelity compatible with the time allowed, and the very defective character of the basis upon which I have had to work. Very early in the course of our investigations, it became apparent that the imperfections of the State map, amounting to innumerable gross omissions and distortions in the topography, would seriously interfere with the proper delineation of the strata, and preclude entirely the exhibition of many interesting details; thus rendering its usefulness as a guide to the intricate mineral districts, particularly a matter of extreme doubt. We therefore entered upon, and have since persevered in, the gratuitous and arduous duty of compiling principally from our own original measurements and observations, a new map, or rather ~~series of maps,~~ embracing all the mountainous country from the Kittatinny valley to the Allegheny mountain, and from the waters of the Lehigh and Lackawanna to Maryland. This has been a self-imposed task, not specifically enjoined by the law, but undertaken through a conviction of its importance to the practical purposes of the survey. The amount of additional labor required, first, in collecting the data for these maps, and secondly, in constructing them upon a uniform and suitable scale, has been very great. Though far advanced, they will hardly be completed before the month of April, as my assistants and myself are much engaged in recording and systematizing the observations of the past year. The several sheets will be reduced and united into two large maps: one comprising all the region N. E. of the Susquehanna, and the other that part of the mountain chain which lies between that river and Maryland. They are to be upon a uniform scale of two miles to the inch, being a linear expansion of two and a-half times that of the State map. Besides rectifying many of the features of the printed map, which are so inconsistent with the geology, that to follow them in delineating the stratification, would be to picture a number of mere physical absurdities; we are enabled, by adopting a large scale, to introduce, in their just and beautiful symmetry, a complicated mass of details, which it would be utterly impossible to crowd into the other cramped and distorted picture of our mountain chain.

Anxious to comply with the letter of the law, I have, at the same time, colored upon the printed map the various formations and mineral belts of the State as accurately and with as much detail as the map itself permitted. A copy of this geological map will be presented with my final report, including such connections as we can introduce from our own original maps, as far as these will go. Notwithstanding the pains taken to delineate the geology of the State upon this map with as few errors and omissions as practicable, such are its inherent defects, that much of the work must go for a mere approximation. Under these circumstances it is for the Legislature to judge whether it would not be wise to authorize the revision and re-engraving of at least the most defective portions of this map, using in its connection the materials embodied in our new geological maps, and the more scattered local data furnished through the numerous public and private railroad and canal surveys, executed of late years and at a great expense, by some of the ablest engineers in the country. The large amount of accurate details in relation to the topography of our State, recorded in the maps and reports of those surveys, many of which were very minute and extensive, ought not to be regarded as so much merely temporary information to be now cast aside. The present moment, when a new edition of the State map is called for by the wants of the geological survey, and by the voice of the public asking for a more accurate guide to our rapidly growing mining districts, seems a fit occasion for placing the map and materials in the hands of some competent geographer to be carefully revised. The cost of making the requisite changes and emendations would not, I am informed, exceed a very moderate sum; and as the present edition is entirely out of print, and the map is waiting, in any event, the action of the Legislature; and as the new demand likely to be created would, in all probability, fully remunerate the State, I would respectfully suggest an early consideration of the subject.

Should the Legislature deem it inexpedient to authorize this correction of the State map, a question presents itself respecting the most suitable form to be given to the general geological map, intended for the illustration of my final report. Some general companion to the report seems indispensable; but whether this should be a geological map, on the basis of the large one, retaining its present defects, or whether it should be one on a reduced scale, better suited for binding up in a portable form with the other drawings, will rest with the Legislature to decide. As convenience for reference is a matter of first consideration in every map, but especially in one to be so constantly consulted, the reduced and more portable scale, if compatible with accuracy and the requisite degree of minuteness, would seem to claim our choice. If the general map intended to accompany the report were made a mere outline of the topography, but corrected from the data now accessible, and if it were made upon one-half the linear scale of the State map, I should deem it a much more valuable basis for the geology than the present large map in an *uncorrected form*. Such a reduction could be made, I believe, at a very trivial cost by any skilful professional map maker. I therefore respectfully suggest to the Legislature the expediency of allowing me to dispense with the large State map as an accompaniment to the report, and of permitting me to set on foot and to superintend the construction of the smaller one proposed.

Our own more detailed geological map of the mountain chain of the State will be completed, it is hoped, by the month of May. But it is desirable, in order to give it neatness and clearness, that a regular topographical draftsman be employed to copy it before it goes to the engraver. This would not materially retard its ultimate *publication*. As my corps of assistants will disperse on the first of April, and as the business of the map maker is in reality foreign from that of the profession of the geologist, and has only now been assumed by us through a strong desire to give our observations an accurate and permanent form, I trust the Legislature will see the propriety of allowing me thus to procure a neat copy of our maps, previous to sending them to the press. Had the appropriation for the incidental expenses of the survey enabled me to embrace this object, I should already have had portions of the maps in the hands of the transcriber. The engraving of the general and more local maps ought, it seems to me, to be expedited as much as practicable, lest the tardy process of finally coloring in the geology may endanger the postponement of the publication beyond the next meeting of the Legislature.

In recommending a reduced and corrected map for the basis of my general geological map of the State, I would not be understood as dissuading the Legislature from a revision of the present large map, the demand for which, were a correct edition published, would, I believe, be very considerable. Though it need not accompany the geological report, as a portion of its essential illustrations, it might be issued, thus revised, in the form of a separate geological map, according to the demand. The utility of affording our citizens, and the public, a general geological map, minute and full enough to be useful for purposes of reference, either in the office or the field, seems sufficiently obvious, and I cannot but believe that the course I propose would materially augment the income from the State map, in which the Commonwealth has invested a considerable capital.

Sections.

The final report and maps will be accompanied by an extensive series of sections, intended to exhibit whatever is important or remarkable in the stratification of the State. Some of these sections will be general and others local, and they will be of two kinds, horizontal or transverse, and vertical or columnar. The horizontal ones are designed to explain whatever relates to the dip, arching, folding, displacement, and thinning and thickening of the strata as they occur in nature. By exhibiting the edges of all the strata as they would be seen if so many long and deep perpendicular cuts were made across their course, they serve to show not only the places where the several rocks and their imbedded minerals rise to the surface or crop-out, but they likewise indicate the direction which they take underground, and their positions and depths for different neighborhoods. These transverse sections, which generally cross the strata, as nearly at right angles to the direction of their out-crop as practicable, form an indispensable key to the map, which represents the course over the surface of the respective formations, but does not exhibit, as the sections do, the range which they take underground. For the sake of easy reference they are drawn upon the same scale as the maps, or on some convenient multiple of it; but many of the local sections intended to illustrate the more confused and complicated portions of the geology will be on a scale many times that of the maps.

One class of these sections, intended to convey correct preliminary notions of the general physical and geological features of the State, will traverse it entirely from north-west to south-east. Another, and much more numerous set, will extend only the breadth of particular districts; while a still more extensive series, will cross only special ranges and basins, whose intimate structure, as in the case of some of our coal fields, cannot be adequately explained but by a multiplication of local drawings. Of the latter class, the anthracite coal basins will of themselves require a very considerable series, amounting probably to one hundred, many of them constructed from actual measurements, and all of them compiled from the best data accessible in the time afforded for the investigation. Their object being to display the coal in all the known relations of its outcrop and position below the surface, they have not been made without very arduous and persevering research, conducted during several seasons in the mines and on the surface. For the devoted manner in which those of my assistants, who were entrusted with the details of this part of the survey acquitted themselves of their duty, to the disregard oftentimes of their health, I wish to enter here my earnest testimony. I sincerely hope, therefore, that the Legislature, in authorizing the publication of a final report on the survey, will permit the engraving, in a clear and proper style, of these hard earned details. Should they be withheld, or be imperfectly executed, I shall despair of rendering many parts of our perplexingly intricate, though abundant coal fields, intelligible to the public.

The vertical or columnar sections, are intended to exhibit in detail, the order of succession and actual thickness of the strata for different districts and neighborhoods. A few of these will be merely general, representing the average relations of the rocks as they occur in regions of considerable area. By far the largest number will be locally illustrative, and will comprise the results of an extensive series of critical examinations and measurements, made at various places, with a view to ascertain and exhibit the precise positions, dimensions and composition, of the several lesser subdivisions of the strata, including even the smallest recognizable mineral beds. By exhibiting a full series of such vertical sections, I shall be enabled to give a much more thorough insight into the local stratification, than I could possibly impart by unassisted description. They will be so drawn, as to convey to the eye at once the whole succession of beds at each particular locality. By comparing together those which relate to the same formation, or the same subdivision of a formation, it will readily be seen what changes each member undergoes, and to what extent given beds or deposites alter their relative thicknesses and distances, or disappear from the series. These sections will also make it apparent at what depths the same beds occur at different places, while they will approximately indicate the position of the more persistent layers for intermediate places, thus serving the purpose of a valuable practical guide to those who may wish to explore any particular neighborhood.

Being especially adapted to exhibit the details of the stratification, in the more gently dipping or horizontal positions of the coal formation, I have introduced them extensively, to illustrate the minute features of the great bituminous coal region north-west of the Allegheny mountain. The strata of that interesting portion of our State, though divided more or less into a succession of parallel troughs or basins, by a series of anticlinal axes, belong originally to one continuous formation. The portions now insulated from each other, by upheaval and denudation, though often separated by a belt of wholly different strata, or even by a bold mountain ridge, are characterized by features of very close identity. It is therefore obvious, that carefully measured vertical sections of the beds may serve as so many more or less correct indexes to the strata of other localities, and even of different basins. This gives them a wide application as a key to the geology. Perhaps no other known coal region, except this wide one of western Pennsylvania and Virginia, admits of so extensive and intelligible a comparison of its stratification, or is so easily illustrated by this neat and simple means of vertical sections. I have, therefore, caused our western strata ~~to be measured~~ at a number of localities, embracing all the basins from the Allegheny mountain, northward and westward throughout the formation, selecting for the points of examination, the best exposures in the hills which border the valleys of the larger streams.

The State Cabinets.

The Legislature at its last session required "the preparation of three complete collections or cabinets of geological and mineralogical specimens for the use of the State," to be severally deposited at Harrisburg, Philadelphia and Pittsburg. The ample collection made, of our rocks, minerals and fossils, can in due time be separated into the three series required, without materially injuring the entireness of either set, as the precaution was early taken to collect, in the greater number of instances, three specimens of each variety. But I regret to state, that ever since the passage of the act imposing this arduous task, my assistants and myself have been so incessantly engrossed, first with duties in the field, and subsequently, with the indispensable labor of preparing our manuscripts, maps and sections, that little has been accomplished towards the arrangement of the three cabinets, beyond what had been previously effected.

To render these cabinets as useful as possible to the public, the specimens should be arranged, I conceive, in an order as strictly conformable as possible with the combined geographical and geological distribution of the subjects in the detailed portion of my final report. In other words, the arrangement of the cases and shelves ought to run parallel with that of the chapters and sections of the book. But to effect this without innumerable mistakes and much waste of time, implies that I shall have made some considerable progress with my final report. As it is, nevertheless, highly desirable that the arrangement of the collections should be completed by the time the final report is through the press, and as the business of setting up the cabinets might go on while I am still at my pen, and much time be thereby ultimately gained, I hope that the Legislature will deem it expedient to take measures for enabling me to proceed with this portion of my task. The first of April next witnesses the dispersion of my corps, the appropriation for our salaries then ceasing. Should the Legislature resolve to give to the public the results of the survey without delay, it seems desirable that some action be taken on the subject of preparing a suitable reception for the three general cabinets.

I have thus, in the foregoing pages, endeavored to exhibit to the Legislature the present posture of the survey, and the best course of action I can suggest for bringing our results and materials speedily and in a useful shape before the public. What I have concisely said in relation to the scope and plan of my forthcoming work, will suffice to show the extent and arduous nature of the task which yet remains to be performed, and will, I trust, procure me the time indispensable for its proper completion. Deprived of the services of my assistants, it will fall to my duty to produce, single handed, a thorough digest of the observations and gatherings of six years, made by a large and fully organized corps.

That the due performance of the duties yet before me will demand at least one year, will be obvious on a brief recapitulation of what remains to be accomplished:—

1st. The composition of the final report, which is to comprise both a general and detailed description of our geology and mineral resources.

2d. The construction and coloring of the general and local geological maps, and a very extensive series of transverse and vertical sections.

3d. The examination of the organic remains, and the preparation of the requisite descriptions and drawings of the characteristic species.

4th. The arrangement and labelling of three extensive collections of specimens, a work, in itself, of considerable time and labor.

5th. Add to these duties that of superintending the press.

Impressed with the serious magnitude of these labors, I have deemed it only my duty to make known the indispensable necessity of time for their performance. The construction of an elaborate scientific work is not like that of a material edifice, the building of which may occupy many laborers to the last. Here the architect must often be himself the sole workman in all that relates to the final arrangement of his materials. In various collateral details he may receive very essential help, and hence I shall feel the burden of my duties seriously augmented by the dispersion of my assistants.

In view of all these considerations, and earnestly anxious to complete my task as early as its faithful performance will allow, I have here ventured upon several suggestions which, if acted on, will tend materially to hasten the completion of the work. Some of these I beg leave, in conclusion, to re-state.

First.—Connected with the early publication of the final report, I would recommend the importance of an appropriation at this time for engraving the maps and sections.

Secondly.—I would suggest that authority be given for procuring out of this appropriation the reduction of the State map to one-half the linear scale of the present plate, the new map to embody the corrections supplied by the geological, and other surveys. Also, that this map be made the basis of the general geological map of the State, and that a part of the fund for publication be applied to procuring a neat and clear copy of the geological and topographical maps of the mountain chain of the State, and for getting them engraved as soon as practicable. It is further recommended that a similar provision be made for a revision and new edition of the State map, to embody all the correct data accessible.

Thirdly.—In regard to the State Cabinets, it is suggested that some steps be now taken for the reception and display of the three large collections of specimens to be severally deposited in Harrisburg, Philadelphia, and Pittsburg.

All which is respectfully submitted.

HENRY D. ROGERS.

PHILADELPHIA, *February* 1, 1842.

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